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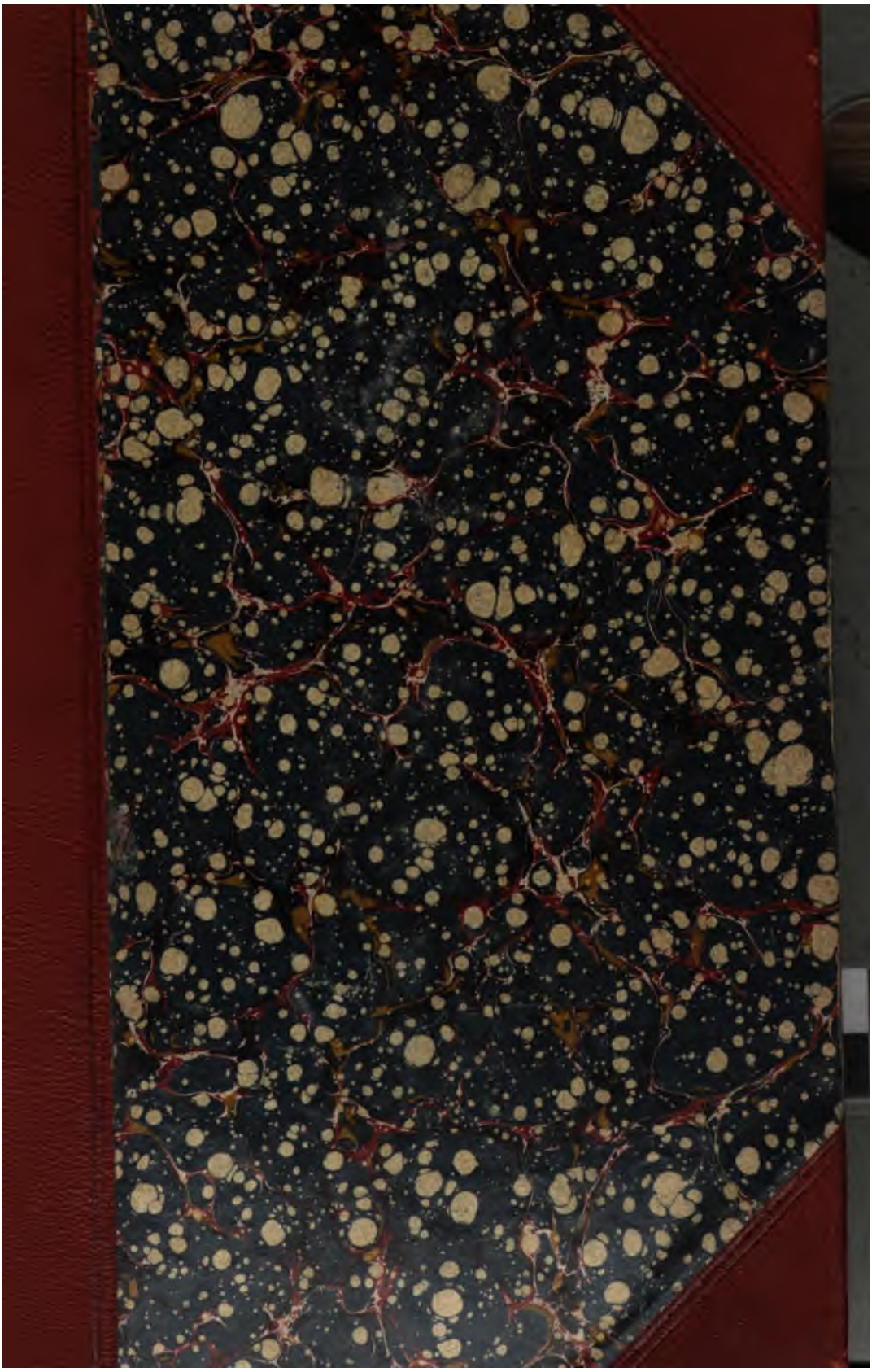

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OF THE

MANCHESTER

GEOLOGICAL SOCIETY.

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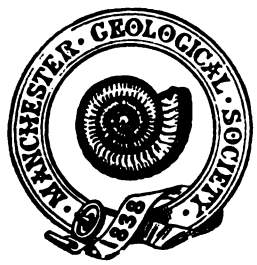
VOLUME FOURTEENTH,

PARTS I.-XXII. 1875-6-7-8.



MANCHESTER:

SOLD AT THE ROOMS OF THE SOCIETY,

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1878.

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*** The writers of papers alone are responsible for the facts and opinions contained in their respective communications.

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MANCHESTER GEOLOGICAL SOCIETY.

Established 15th October, 1838.

OBJECTS.

The objects of the MANCHESTER GEOLOGICAL SOCIETY *are the collection and diffusion of Practical and Theoretical Knowledge respecting Geology and Mining. In furtherance of such objects, original Papers on Geology and Mining subjects—either written by the members of the Society, or communicated to the Society through a member, on behalf of the authors—shall be read and discussed at its meetings, and if judged to be of sufficient interest, shall be printed at the expense of the Society, in its Transactions.*

RULES.

I.—The Society consists of Ordinary, Life, Honorary, and Corresponding Members.

II.—Every candidate for admission into the Society as an ordinary member, must be proposed by two or more members, who must sign a certificate in recommendation of him, setting forth the name, description, and place of residence of the candidate.

III.—The certificate, when duly filled up, shall be read aloud at the next ordinary meeting of the Society; and the election of the candidate shall forthwith be decided by a majority of votes.

IV.—The Secretaries shall address to every person elected a member, a notification of such election, with a copy of the printed Rules and Bye-laws of the Society.

V.—No person elected a member shall be entitled to exercise any privilege as such, until he shall have paid his annual subscription, or the composition in lieu thereof.

VI.—The annual subscription to be paid by ordinary members shall be twenty shillings, due on each successive first day of October, and payable in advance for the current year, and shall be a debt due to and recoverable as such by the Treasurer for the time being.

VII.—Members joining the Society on or after the first day of April in any year, shall pay the sum of ten shillings as the subscription for the current year.

VIII.—An ordinary member may, at his election, or any future period, become a life member by compounding for future annual subscriptions, including that of the current year, by the payment of ten pounds. If he has already paid the subscription for the current year, or any part of it, such payment shall be allowed in part of his composition.

IX.—The payment by an ordinary or life member, of the subscription, or the composition in lieu thereof, shall imply the acquiesence of such member in the Rules and Regulations of the Society, and shall entitle him (so long as no subscriptions remain unpaid) to admission to the meetings of the Society, the use of the Library, and to one copy of each of the Transactions, and of any other publications the Society may print.

X.—Individuals distinguished for their Geological or Mining reseaches, for their liberality to the Society, or for their connexion with other Societies, may, on the recommendation of the Council, be elected honorary or corresponding members of this Society at any ordinary or general meeting. But such honorary or corresponding members shall have no vote in the affairs of the Society.

XI.—Any member may withdraw from the Society by signifying his wish to do so, by letter under his hand, to the Secretaries, at the apartments of the Society; provided always, that such member shall be liable for the subscription for the whole year wherein he signifies his wish to withdraw; and shall continue liable to future annual subscriptions until he have discharged all sums due from him to the Society, and returned all books and

other property, if any, in his custody, belonging to the Society; or shall have made full compensation for the same if lost or not forthcoming after two months' notice from the Secretaries.

XII.—As soon as any member has let his subscriptions fall two years in arrear, the Secretary shall notify the fact to him, and require him to pay what is due within one month. In case of non-compliance with such request, the Council may determine the membership of the defaulter.

XIII.—An annual meeting of the Society shall be held in the month of October, for the purpose of electing the officers for the current year, receiving the Annual Report of the Council, together with an Audited Statement of the Receipts and Expenditure of the last year, and transacting the general affairs of the Society. At this meeting any member may question the Council upon any matter contained in such report, and comment thereon, and on any other matters of which notice in writing had been previously given to the Council, relating to the affairs of the Society, as to him may appear proper.

XIV.—Ordinary meetings of the Society shall be held once, at least, in every month, from October to June, inclusive, at such time as the Council shall appoint. Each member shall have the power to introduce visitors to the meetings, on entering their names in a book to be kept for that purpose.

XV.—Ordinary meetings may be held in other localities than Manchester, according to the pleasure of the Society, to be determined at a previous meeting.

XVI.—Circulars announcing meetings of the Society, or of the Council, shall be sent, free of postage, to the respective members of those bodies, at least three days before such meeting.

XVII.—Special general meetings may be summoned by the Council, or by the Secretaries, on the requisition, in writing, of any six members of the Society, by notice delivered free, or sent by post, pre-paid, to all the members whose addresses are known, not less than one week, nor more than a fortnight, before any such meetings. Such notice shall state the time and place of

holding the meeting, and the specific purposes for which it is convened; and the business of such meeting shall be restricted to such purposes.

XVIII.—At the hour appointed for a meeting of the Society or Council, the chair shall be taken by the President, or the senior Vice-President present, and in their absence the meeting shall, previously to entering upon any other business, elect some member present to be Chairman.

XIX.—All questions discussed at any such meeting, except as otherwise provided, shall be decided by a majority of votes; and if upon any question the votes shall be equal, the Chairman of the meeting shall have a second vote as a casting vote.

XX.—No business shall be done at any such ordinary or special meeting unless when five members at least are present, except that any number of members who may be present, not being less than two, may adjourn the meeting to a future day, such adjourned meeting to be summoned in the same manner as the original meeting.

XXI.—A President, four Vice-Presidents, two Honorary Secretaries, and a Treasurer, shall be elected at each annual meeting; and the foregoing, together with twelve ordinary members, to be elected at the same time, shall form the Council of the Society, and shall have the management of its affairs, except as is otherwise provided by these Rules; and at the same meeting two Auditors shall be elected for the year ensuing. These elections shall be by ballot. In addition to the four Vice-Presidents annually elected, the Ex-Presidents shall be *ex post officio*, Vice-Presidents of the Society.

XXII.—Any member who has been for six months a member of the Society, and whose subscription is not in arrear, shall be eligible to be elected an officer or member of the Council.

XXIII.—In the event of any vacancy occurring during the year in the Officers or Council, the same shall be filled up by the Council.

XXIV.—The President shall not be eligible for that office for more than two years in succession; and the two Vice-Presidents,

and the four members of the Council who shall have attended the meetings of Council the least number of times, shall be ineligible to the same office for the ensuing year.

XXV.—The Council shall have power to make Bye-laws and Regulations, in accordance with the general Rules of the Society, to appoint, suspend, or dismiss salaried agents, clerks, or servants; to purchase and collect books, maps, models, specimens, and other objects; to provide rooms for the meetings of the Society, and pay rent for the same; and to purchase furniture or other articles that they deem necessary for the use of the Society.

XXVI.—The Council shall meet once at least in every month, and upon such other occasions as they may deem expedient. Special meetings of the Council may be called by either of the Secretaries, or on the requisition of any three members of the Council, of which number the officer convening such meeting may be one; any three members of the Council present at a meeting being sufficient to constitute a quorum.

XXVII.—A minute of the proceedings of all meetings shall be entered by the Secretaries in a book to be kept for that purpose.

XXVIII.—The Council shall decide whether a paper shall be printed in the Transactions or not, and if they do not unanimously agree to print it, or reject it, they may refer it to one or more members of the Society, to report upon its merits, and, in exceptional cases, refer it to competent persons who are not members. After having received such reports, the Council shall decide without delay whether or not the paper is to be printed. The author of a paper shall be at liberty to reserve his right of property therein, and shall have a right to withdraw it from publication, by giving timely notice to the Council.

XXIX.—All moneys, the Library, and all chattels of the Society, shall be held by the President and Treasurer for the time being, as legal owners thereof, but in trust for the Society, and under the direction of the Council, and all investments shall be made in the names of such members, not being less than two, as the Society may from time to time appoint.

XXX.—All the funds and moneys of the Society shall be applied by or under the direction of the Council, in paying the debts and demands for the time being owing by the Society, and carrying out the purposes thereof as defined in the preceding Rules; and no dividend, gift, division, or bonus in money shall at any time, or under any circumstances, be made unto or between the members of the Society, or any of them.

XXXI.—No additional rule, nor any alteration or repeal of any existing or future rule or rules of the Society shall be made, unless with the consent of three-fourths in number of such of the ordinary and life members as may be present at any annual or special meeting; and the proposed change must be announced by circular to the members whose addresses are known, at least three weeks before such meeting.

XXXII.—The Society shall not be dissolved, nor shall the Library or other property be disposed of, unless with the consent, in writing, of three-fourths of such of the ordinary and life members as may be present at each of two successive special general meetings, duly convened by public advertisement in the Manchester daily newspapers, and by notice sent by post at least one calendar month before each meeting, to all members, whose addresses are known; such meetings to be held at an interval of not less than two, nor more than four, calendar months.

BYE-LAWS

FOR

REGULATION OF THE LIBRARY.

I.—No Book, Map, or document shall be taken from the Library without the same being first entered in a Register, in such manner as the Council shall from time to time direct.

II.—The time allowed for retaining a Book, &c., shall not exceed one calendar month.

III.—No Member shall be allowed to renew a Volume, Map, &c., in case any other Member shall have entered his name as being desirous of taking out the same on its return. Such Volume, Map, &c., shall, on its return from the person holding the same, be entered as taken out by the Member so applying, and shall not be taken away by any Member, save him in whose name it is entered, till the expiration of the period for which the Member in whose name it is entered would have been entitled to hold the same. At which period the said Book, &c., (in case the same shall not have been taken out by the party in whose name it is entered on the Register,) shall be returned in the Register as returned.

IV.—The time allowed for holding shall, in every case, be computed from the date of the entry in the Register.

V.—Every Member shall return the Books, Maps, and documents belonging to the Society in as good a condition as when they were delivered into his possession, and shall be answerable for the same till their return from him, to the Society, is correctly entered in the Register.

By order of the Council,

JOHN EDWARD FORBES, F.G.S.,
JOHN PLANT, F.G.S., } HONORARY SECRETARIES.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART I. VOL. XIV. SESSION 1875-6.

ANNUAL MEETING.

The ANNUAL MEETING of the Members of the Society was held on Tuesday, the 26th October, in the Literary and Philosophical Society's Rooms, George Street, Manchester. Mr. JOSEPH DICKINSON, F.G.S., Vice-President, in the chair.

The following Report of the Council was read by Mr. J. E. Forbes, one of the Honorary Secretaries:—

REPORT OF THE COUNCIL FOR 1874-5.

The Council have very great pleasure in being able to report that the proceedings of the Society, in all respects, during the past session have been satisfactory, and that the anticipations which were made of greater activity and support from the members, when the Society commenced holding its meetings in the present rooms, have been fully realised.

The Society at the present time consists of the following members:—

Life Members	8
Honorary Members	16
Ordinary Members	101
Total	125

During the last session twelve new members have been elected, whilst there have been five losses by deaths and resignation in the course of the session. Allusion has already been made to the loss of one of the most eminent geologists, Sir Charles Lyell, who was for many years an honorary

member of the Society, and also to the death of the distinguished engineer T. E. Forster, also an honorary member, to Robert Hyde Greg, T. T. Wilkinson, and W. R. Barr.

According to the "Articles of Agreement"—of which a copy is appended to this Report—between the Geological Society and certain Commissioners, to carry into effect the transfer of the Geological Museum to The Owens College, the Museum should now have been opened to the public, except on the reserved days; but, owing to the rooms at The Owens College not having been completed, it has been found inconvenient to do so, except under restrictions to prevent crowding. This inconvenience to the members and to the public it is hoped will soon be remedied.

The Library has been completely arranged in a new cabinet, many of the recent books bound, and a classified catalogue printed for the use of the members. The Council have added several important works on Mining, Geology, and Palæontology, and it is gratifying to make mention of the several donations to the Library which have been received from kindred Societies in Great Britain, Europe, India, Canada, and from the United States. These publications are of a high scientific character, and the members have special advantages in being able to consult these important memoirs.

The printing of the "Transactions" has been effected as regularly as the accumulation of matter would allow, and four parts have been issued during the session. The matter in hand will form the concluding part of Vol. XIII.

The Council have no hesitation in offering an opinion that the papers read during the session will bear favourable comparison with those of any previous session, and the discussions at the meetings have been sustained with an evident interest on the part of the members. The sale of the "Transactions" to the public is satisfactory, as will be seen in the Treasurer's account.

Several field excursions were proposed during the session, but the arrangements as to a time convenient to many of the members were not satisfactory, and consequently none took place. If this feature in the work of the Society is desirable, it will probably be successful if all the arrangements were entrusted to a special Sub-Committee, and two or three Geological excursions might be carried out in the summer of 1876.

The Financial Account with the Treasurer is appended, in which it will be seen that an additional £100 has been invested in Birkenhead Stock, making a total of £600 so invested.

NEW ORDINARY MEMBERS.

Bangay, Dr., Cheadle, Cheshire.
Barrett, W. S., 49, Oldhall Street, Liverpool.
Burrows, Abraham, Atherton Collieries, near Manchester.
Crofton, Rev. A., Wyngate House, Levenshulme.
Diggle, A. A., Hindley Green Hall, Leigh.
Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
Gun, Capt. H. A., R.E., F.G.S., Royal Engineers' Office, Manchester.
Hetherington, Joseph, 17, Dickinson Street, Manchester.
Jackson, J., 5, Wood Street, Bolton.
Morris, Daniel, Grammar School, Burnley.
Nesbitt, George, 100, Burlington Street, Manchester.
Waters, A. W., F.G.S., Woodbrook, Alderley Edge.

DECEASED.

Barr, W. R.
Greg, R. H.
Forster, T. E.
Lyell, Sir C.
Wilkinson, T. T.

Dr. MANCHESTER GEOLOGICAL SOCIETY, BALANCE SHEET. Cr.

Abstract of Receipts.

1874.	£	s.	d.
To Balance brought down.....	150	2	8
,, Bank Interest	3	17	0
,, Birkenhead Dividends	23	16	0
,, Sale of Proceedings	8	18	0
,, Subscriptions and Arrears	97	0	0
	£283	13	8

To Balance brought down October, 1875.. £44 11 6

HENRY M. ORMEROD,
Treasurer.

Abstract of Payments.

1875.	£	s.	d.
By Library.....	75	0	3
,, Reporters	8	8	0
,, Transactions and Reports of Meetings ..	1	5	0
,, Postages and Stationery	19	16	5
,, Collectors' Commission.....	4	17	0
,, Insurance	0	3	0
,, Rent	30	0	0
,, Purchase of £100 Birkenhead Stock ..	99	12	6
	239	2	2
,, Balance	44	11	6
	£283	13	8

The Stock belonging to the Society consists of £600 Birkenhead Railway Stock, standing in the names of Henry Mere Ormerod and Andrew Knowles.

THE FOLLOWING PAPERS AND COMMUNICATIONS HAVE BEEN BROUGHT BEFORE THE ORDINARY MEETINGS DURING THE SESSION.

1874.

Nov. 24. The President's (W. Boyd Dawkins, F.R.S.) Inaugural Address.

Dec. 23. "On Fish Remains from the Coal Measures," by Mr. J. Aitken.

"The Geology of the Parish of Halifax," 3rd part, by Mr. J. Spencer.

1875.

Jan. 26. "On Tertiary Coals," by Mr. A. W. Waters.

"The Geology of Halifax," by Mr. J. Aitken.

Note by the President.

"The Hematites of Whitehaven and Furness," by Mr. J. D. Kendall.

Feb. 23. "Discussion on Mr. Kendall's Paper on Hematites."

"On Basalt and its effects," by Mr. G. C. Greenwell.

March 23. "Discussion upon Mr. Greenwell's Paper on Basalt."

"On a Greenstone from Glyn Ceiriog," by Mr. C. Hardwick.

"On the Origin of Arenaceous Nodules in Coal Measures,' by Mr. J. Plant.

April 27. "On Belemnites of Eocene Age," by Mr. A. W. Waters.

"On Lead Mining in the Rossendale District," by Mr. J. Kerr.

May. No Meeting.

June 29. "On the Phenomena of the Great Eruption of Vesuvius, 1872," by Mr. W. J. Black.

"Observations on the Castleton Bone Deposit," by by Mr. J. Plant.

"On Alluvial Gravels in Salford," by Mr. J. Plant,

The Report was adopted, and ordered to be printed.

The following gentlemen were then proposed and seconded, and declared duly elected as Officers and Members of the Council for the ensuing year:—

President.

CLIFFORD SMITH, F.G.S.

Vice-Presidents.

JOSEPH DICKINSON, F.G.S.
JOHN AITKEN, F.G.S.
THOMAS KNOWLES, M.P.
PROFESSOR BOYD DAWKINS, F.R.S.

Treasurer.

HENRY MERE ORMEROD, F.G.S.

Secretaries.

JOHN EDWARD FORBES, F.G.S.
JOHN PLANT, F.G.S.

Council.

E. W. BINNEY, F.R.S.
R. D. DARBISHIRE, F.G.S.
RALPH FLETCHER, Jun.
G. C. GREENWELL, F.G.S.
W. H. HEWLETT.
W. H. JOHNSON.
ANDREW KNOWLES.
JOHN KNOWLES, M.I.C.E.
J. S. MARTIN.
EDWARD PILKINGTON.
A. W. WATERS, F.G.S.
JOHN WILD.

Auditors.

JOHN HEELIS.
THOMAS LIVESEY.

LIST OF MEMBERS,

NOVEMBER, 1875.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1874	*Agassiz, Alexandre*, Cambridge, Massachussetts, U.S.
1863	Aitken, John, F.G.S., Bacup, *Ex-President*.
1862	Alcock, Thomas, M.D., Oak Field, Ashton-on-Mersey.
1865	Ashworth, Edward, Stagg Hills, Waterfoot, near Manchester
1864	Ashworth, John, Rose Hill, near Bolton.
1866	Bamford, J. B., Mining Engineer, Rochdale.
1875	Bangay, Dr., Cheadle, Cheshire.
1875	Barrett, W. S., 49, Old Hall Street, Liverpool.
1858	Bazley, Sir Thomas, Bart., M.P., Eyford Park, Stow-on-the-Wold, Gloucestershire.
1862	Beswicke, William, South Parade, Rochdale.
1838	Binney, E. W., F.R.S., F.G.S., 55, Peter Street, Manchester. *Ex-President*.
1867	Bolton, H. H., Newchurch, near Manchester.
1866	Brierley, Joseph, Civil Engineer, Blackburn.
1859	*Brongniart, Adolphe*, Jardin des Plantes, Paris.
1861	Brooks, Thomas, Sunnyside, Rawtenstall.
1859	Bryham, William, Rose Bridge Colliery, Wigan.
1862	*Buccleugh, His Grace the Duke of, Whitehall Gardens, London, S.W.
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1874	Byrom, W. A., F.G.S., 27, King Street, Wigan.

Year of Election.	
1874	Crofton, Rev. A., Wyngate House, Levenshulme.
1860	Crowther, Samuel, Bradford Offices, Bolton.
1859	*Coulthard, J. Ross, F.R.S.L.. Croft House, Ashton-under Lyne.
1862	Cross, John, 78, Cross Street, Manchester.
1861	Cross, John, Gidlow House, Wigan.
1868	Craig, William Young, Alsagar, Stoke-on-Trent.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., The Owens College, Manchester. *Ex-President.*
1862	Derby, The Right Hon. the Earl of, Knowsley.
1860	Darbishire, R. D., B.A., F.G.S., 26, George Street, Manchester.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *Ex-President.*
1875	Diggle, A. A., Hindley Green Hall, Leigh.
1859	Diggle, James, Westleigh Colliery, Leigh.
1866	Eccles, James, F.G.S., 15, Durham Villas, Phillimore Gardens, Kensington, London, W.
1838	*Egerton, Sir Philip de Malpas Grey, Bart., M.P., F.R.S., Oulton Park, Tarporley. *Ex-President.*
1852	Egerton, The Hon. Algernon, M.P., Worsley Hall.
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1838	*Enniskillen, Earl of*, F.R.S., Florence Court, Fermanagh.
1860	Eskridge, R. A., F.G.S., 18, Hackin's Hey, Liverpool.
1865	Evans, Walter, Middleton, near Manchester.
1863	Farrer, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1857	Forbes, John Edward, F.G.S., 5, York Street, Manchester.

Year of Election.	
1873	Garforth, W. E., Lord's Field Colliery, Ashton-under-Lyne.
1874	*Geikie, Archibald,* LL.D., F.R.S., Ramsay Lodge, Edinburgh.
1858	Gerard, Lord, Bryn and Garswood, near Warrington.
1856	Gilroy, George, Ince Hall Colliery, Wigan.
1852	Greg, Robert Philips, F.G.S., Coles Park, Buntingford, Herts.
1863	Greenwell G. C., F.G.S., Poynton, near Stockport. *Ex-President.*
1874	Greenwell, G. C., junr., Poynton, near Stockport.
1865	Grimshaw, W., Wellfield, Stand, Whitefield, near Manchester.
1874	Gun, Captain, H.A., R.E., F.G.S., Royal Engineers' Office, Manchester.
1838	Hadfield, George, 24, Fountain Street, Manchester.
1866	Hall, John, Balderstone, Walmersley.
1864	Hall, Robert, Hope Foundry, Bury.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 74, Halston Street, Hulme.
1874	*Hawkins, B. W.*, F.G.S., Century Club, East 15th Street, New York.
1874	*Hawkshaw, Sir John,* Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1862	Hawksworth, E., Crewe Coal and Iron Co., Crewe.
1860	Heelis, John, 37, Cross Street, Manchester.
1875	Hetherington, Joseph, 17, Dickinson Street, Manchester.
1874	Hewlett, W. H., Wigan Coal and Iron Co., Wigan.
1838	*Heywood, James, F.R.S., F.G.S., 26, Kensington Palace Gardens, London, W. *Ex-President.*
1862	Heywood, Oliver, Acresfield, Pendleton.
1874	*Hull, Professor Edward,* M.A., F.R.S., 14, Hulme Street, Dublin.

Year of Election.	
1875	Jackson, J., 5, Wood Street, Bolton.
1874	Johnson, J. H., F.G.S., Strangeways, Wigan.
1858	Johnson, Richard, 27, Dale Street, Manchester.
1870	Johnson, W. H., B.Sc., Wilmslow.
1844	*Joule, J. P., LL.D., F.R.S., Old Trafford, Manchester.
1856	Knowles, Andrew, High Bank, Pendlebury. *Ex-President.*
1859	Knowles, John, Westwood, Pendlebury. *Ex-President.*
1864	Knowles, Kaye, Swinton Old Hall, Pendlebury.
1858	Knowles, Thomas, M.P., Ince Old Hall, Wigan. *Ex-President.*
1858	Lancaster, John, F.G.S., Bilton Grange, Rugby.
1860	*Litler, H. William, Wallerscote, Leamington.
1862	Livesey, Clegg, Bredbury Colliery, near Stockport.
1838	Livesey, Thomas, Prestwich Park, near Manchester.
1861	Lynde, J. G., F.G.S., Town Hall, Manchester.
1873	Martin, Joseph S., Inspector of Mines, Park Villas, Prestwich.
1875	Morris, Daniel, Grammar School, Burnley.
1838	*Morton, Charles*, The Grange, Southport.
1874	*Morton, G. H.*, F.G.S., 21, West Derby Street, Liverpool.
1875	Nesbitt, George, 100, Burlington Street, Manchester.
1864	Nuttall, Thomas, Colliery Surveyor, Bury.
1874	*Ormerod, G. W.*, M.A., F.G.S., Brookbank, Teignmouth.
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester.
1874	*Owen, Professor Richard*, D.C.L., F.R.S., &c., British Museum, London, W.C.
1864	Park, James, Ironfounder, Bury.
1873	Pilkington, Edward, Clifton Collieries, near Manchester.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester.
1861	Pickup, Peter, F.G.S., Townley Colliery, Burnley.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford.

Year of Election.	
1867	Radcliffe, James, Lord's Field Colliery, Ashton-under-Lyne.
1866	Radcliffe, Richard, Preston New Road, Blackburn.
1874	*Ramsay, Professor A. C.*, LL.D., F.R.S., &c., 15, Cromwell Crescent, South Kensington, S.W.
1860	Ridyard, John, Walkden, Worsley.
1873	Seddon, J. F., Great Harwood Collieries, Accrington.
1866	Selby, Atherton, M.E., Leigh.
1858	Shuttleworth, Sir James P. Kay, Bart., F.G.S., Gawthorpe Hall, Burnley. *Ex-President.*
1864	Smethurst, William, Garswood Hall Colliery, Ashton, near Wigan.
1838	Smith, G. Fereday, M.A., F.G.S., Grovehurst, Tunbridge Wells.
1873	Smith, Clifford, F.G.S., Parkfield, Swinton, near Manchester.
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall.
1844	*Sopwith Thomas*, M.A., F.R.S., F.G.S., 103, Victoria Street, London, S.W.
1862	Spence, Peter, F.C.S., Erlington House, Seymour Grove, Old Trafford.
1859	Statter, Thomas, Stand, Bury.
1858	*Trafford, Sir Humphrey De, Bart., Trafford Park.
1873	Tonge, James, Hulton Colliery, near Bolton.
1862	Wadham, Edward, Millwood, Dalton-in-Furness.
1862	*Walsh, Eli, Over Darwen.
1874	Waters, A. W., F.G.S., Woodbrook, Alderley Edge.
1863	Webster, R. C., Ruabon Colliery, Ruabon.
1865	Whipp, Thomas, Sandy Lane, Bowdon.
1867	Wild, George, Bardsley Colliery, Ashton-under-Lyne.
1859	Wild, John, Glodwick, Oldham.
1860	Wild, Samuel, Dean House, Buersill, Rochdale.
1838	*Wilson, Thomas*, Hillary Place, Leeds.
1859	Woods, Henry, The Larches, Wigan.
1874	*Woodhouse, J. T.*, F.G.S., M.I.C.E., Overseal, near Ashby-de-la-Zouch.

PAST PRESIDENTS OF THE SOCIETY.

1838-9-40	Egerton, The Rt. Honourable Francis, M.P.
1841-2-3	Heywood, James, F.R.S., F.G.S.
1843-4-5	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1849-50-1	Heywood, James, M.P., F.R.S.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1855-6-7	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1857-8-9	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart., F.G.S.
1861-2-3	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1865-6-7	Binney, E. W., F.R.S., F.G.S.
1867-8-9	Greenwell, G. C., F.G.S.
1869-70-1	Aitken, John, F.G.S.
1871-2-3	Knowles, John, M.I.C.E.
1873-4	Knowles, Thomas, M.P.
1874-5	Dawkins, Professor Boyd, F.R.S., F.G.S.

Articles of Agreement

made the 30th day of November, 1869, BETWEEN JOHN AITKEN, F.G.S., President of the Manchester Geological Society, acting for and on behalf of the said Society of the first part; and ARTHUR GEORGE LATHAM, Merchant, JOSEPH SIDEBOTHAM, Calico Printer, JAMES PRESCOTT JOULE, Esquire, THOMAS HENRY NEVILL, Calico Printer, all of the City of Manchester, in the County of Lancaster, Commissioners appointed for and on behalf of the late Natural History Society of Manchester; THOMAS ASHTON, Merchant, JOSEPH GEORGE GREENWOOD, Esquire, both of Manchester aforesaid, acting for and on behalf of the Extension Committee of Owens College, in Manchester aforesaid, and ALFRED NIELD, Esquire, and MURRAY GLADSTONE, Esquire, both of Manchester aforesaid, acting for and on behalf of the Trustees of Owens College, of the second part.

WHEREAS, by a certain Indenture, bearing date the 29th day of January, 1868, the whole of the collections of the Manchester Natural History Society became, or were to become, upon certain conditions, the property of the Trustees of Owens College, except the Geological part of the same. And whereas, in pursuance of certain arrangements, the Geological and Mineralogical Collection of the Manchester Geological Society was united with the Geological and Mineralogical Collection of the Manchester Natural History Society into one collection, and so remains united. And whereas, in and by the before-mentioned indenture, it was declared that the said several persons parties hereto, of the second part, or such of them as were acting for the time being, might forthwith, or at any time within five years from the date thereof, arrange with the said Manchester Geological Society as to the disposal of the joint collection of Geological Specimens in the said Museum, and might, if they or he should think fit, cede to the said Geological Society such portion of the said Geological Collection as was the property of the said Manchester Natural History Society, provided that no disposition should be made of the said Geological Collection which should prevent its continuance as one entire collection within the

parish of Manchester aforesaid, or the gratuitous admission of the public thereto. And whereas it has been considered desirable that the said collections should still remain united, and in pursuance of such intention it has been determined by two successive general meetings, duly convened and held in pursuance of "The Literary and Scientific Institutions' Act, 1854," by the votes of three-fifths of the members present at each of such meetings, that all, and singular, the part, share, estate and interest whatsoever of the said Manchester Geological Society of and in the said united collection shall become and be vested in the said parties hereto, of the second part, upon the trusts hereinafter mentioned, and that the said G. C. GREENWELL, F.G.S., as such President, as aforesaid, and in the name of the said Society, shall be authorised and directed to enter into the agreement and declaration hereinafter contained, for and on behalf of the Council and Members of the Manchester Geological Society. And whereas the Committee for the Extension of Owens College, as well as the said several persons, parties hereto of the second part, have by resolutions severally, bearing date respectively the 30th day of June, 1869, agreed to accept such part, share, and interest, upon the trusts hereinafter declared. Now therefore these presents witness, and it is hereby declared and agreed that from henceforth all and every the part and share, or parts and shares, undivided or otherwise, of the said Manchester Geological Society of and in the united collection of Geological and Mineralogical Specimens, and of and in all cases containing the same, now belonging to and held by the said Society, jointly or in common with the late Manchester Natural History Society, and all the right, title, interest, trust, claim and demand of the said Manchester Geological Society, and of the Council and Members thereof, shall from henceforth be and become vested in the said several persons, parties hereto of the second part, their executors, administrators, and assigns, to, for, and upon such trusts, ends, intents and purposes, and with, under, and subject to such powers, provisions, declarations, and agreements as are hereinafter declared and contained of and concerning the same; that is to say, upon trust that the said parties hereto, of the second part, and the survivors and survivor of them, and the executors and

administrators of such survivor, their or his assigns, hereinafter called the Natural History Commissioners, do and shall stand possessed of the said united Geological and Mineralogical Collection, and other the premises hereinbefore mentioned, and all additions thereto, upon trust, until the 28th day of January, 1873, or until it shall sooner appear to the satisfaction of the said Natural History Commissioners that the objects of the said Extension Committee of the said College, with respect to the extension of the said College, and the erection of new buildings in connection therewith, have been, or in all reasonable probability will be attained, to permit and suffer the said collection and premises to be used and enjoyed as a Museum, without charge, for the purpose of the said College; and also by the public, and by the members of the Manchester Geological Society, and such other persons as they may think fit, in conformity with and subject to such rules and regulations for the management and conduct thereof as the said Natural History Commissioners, jointly with the four persons to be nominated by the Council of the said Manchester Geological Society, as hereinafter directed, hereinafter called "The Geological Commissioners," shall from time to time direct.

For the purposes aforesaid, and during the period aforesaid, it shall be lawful for the said Natural History Commissioners, jointly with the said Geological Commissioners, to reorganise the said collection, and to receive new specimens in addition thereto, and to exclude and sell or exchange, or otherwise dispose of, duplicate and any other undesirable specimens, and to maintain the said collection, with all needful appliances and improvements, and expenses of insurance, Curatorship, and conservancy.

If at any time before or at the said 28th day of January, 1873, it shall appear to the satisfaction of the said Natural History Commissioners that the objects of the said Extension Committee of the said College, with respect to the extension of the said College, and the erection of new buildings in connection therewith, have been, or in all reasonable probability will be attained, the said Natural History Commissioners and all other necessary parties shall assure to Trustees for the time being, of or for the said enlarged College, their executors, administrators, and assigns, all and

singular the said collection and premises hereinbefore mentioned, and all additions thereto, to the intent that the same collection and premises may be held and disposed of and applied by the Trustees, for the time being, of the said enlarged College, in the manner hereinafter expressed, for the promotion of Natural History in Manchester, and for the purposes of the same College, and for the benefit of the public, and with the privileges for the present and future members of the Manchester Geological Society, and for the same Society, and according to the provisions and subject to the conditions hereinafter expressed, that is to say:—

1. The said united collection (with all additions, and subject to the reasonable exclusion of duplicate or otherwise undesirable specimens) is to be maintained in an appropriate Museum, or appropriate Museum rooms to be provided for the same.

2. The same, with all specimens added thereto, is to be maintained, with all needful appliances and expenses of Curatorship and conservancy.

3. An efficient Curator or efficient Curators is or are to be from time to time appointed by the Trustees of the said enlarged College, and to be removable by them; and the duty of such Curator or Curators shall be to superintend and manage the said collection; and the salary of such Curator or Curators is to be provided by the Trustees of the said enlarged College, from the income of any funds applicable to such purpose, provided that the office of Curator may be united with that of Curator or sub-Curator of the Natural History Museum, intended to be constituted under the charge of the Trustees of the said intended enlarged College, or with that of a Professor or Lecturer of the said enlarged College.

4. The said collection shall be closed on one day in each week for cleaning and other purposes; and shall be open, without charge, on two days in each week for the purposes of study, to all persons, under regulations to be made from time to time by the Trustees of the said enlarged College; and shall be open, without charge, to the public on three days in each week, with occasional evening access, according as the said Trustees of the said enlarged College may direct; and the said Trustees of the said enlarged College may close the said collection for any time not exceeding in the whole

six weeks in each year. The Professors and Lecturers in the said College, under such regulations as aforesaid, shall have the use in the said College of the specimens in the said Museum.

5. The members of the Manchester Geological Society for the time being shall have, so far as may be consistent with the preceding provisions, the like access to the said collection, in the said Museum, for themselves and their friends, as they now enjoy in respect of the present collection, and shall have access for themselves on the two days in each week set apart for study.

6. The said Manchester Geological Society shall have, from time to time, the free use of such Geological and Mineralogical Specimens as they may require for their monthly or other meetings, they being at the expense of the removal and replacing the same. If at the expiration of the said term, viz., on the 28th day of January, 1873, it shall appear to the said Natural History Commissioners and the said Geological Commissioners that the objects of the said Extension Committee of the said College, with respect to the extension of the said College, and the erection of new buildings in connection therewith, have not been, or are not likely with all reasonable probability to be attained, then the said Natural History Society Commissioners shall stand possessed of the said united collection, and all additions thereto, upon such trusts and for such purposes, for the promotion of Natural History in Manchester, as they and the said Geological Commissioners shall jointly agree upon; and in case of difference, then upon the same trusts and for the same purposes as the said united collection now stands vested, and as if these presents had not been made.

The Council of the Manchester Geological Society shall, from time to time, nominate and appoint four persons, members of their Society, to act for such period as the Council shall think fit, with liberty to remove the same at discretion; and the vacancy caused by such removal, or the death, resignation, or otherwise of any of such persons, from time to time, to appoint another in lieu thereof; and such persons so appointed, herein called Geological Commissioners, shall and may act jointly with the said Natural History Commissioners, for the purpose of reorganising the said collection, receiving new specimens in addition thereto, excluding, selling, or

exchanging, or otherwise disposing of duplicate and any other undesirable specimens, and maintaining the said collection, with all needful appliances and improvements.

The said Manchester Geological Society, so long as the said Natural History Commissioners shall continue to occupy the Museum Buildings, in Peter Street, in Manchester aforesaid, shall be furnished and provided with rooms for their meetings and Library on the same terms and conditions as at present, but such occupation and provision shall absolutely cease and determine in the event of the said Natural History Commissioners ceasing to occupy the said buildings.—IN WITNESS, &c.

LISTS OF PRESENTS FOR THE LIBRARY RECEIVED TO OCTOBER, 1875.

TRANSACTIONS :—

1. London Geological Society.—"Quarterly Journal." Nos. 119 to 124, and Abstracts for the Session, 1874-5. From the Society.
2. London Geologists Association.—"Proceedings." Nos. 1, 2, 3, 4. Vol. 4. Annual Report, 1874. From the Council.
3. South Wales Institute of Engineers.—"Proceedings." Parts I., II. No. 2. Vol. 1. December, 1874. Including "The South Wales Coal Field," by J. F. Brown. Large Map and Sections. From the Council.
4. Miners' Association of Cornwall and Devon.—"Reports and Proceedings for 1873." From the Council.
5. Royal Geological Society of Ireland.—"Journal." Part 1. Vol. 4. N. S. 1873-4. From the Council.
6. Geological Society of Glasgow.—"Transactions." Part I. Vol. 5. 1875. From the Council.
7. Royal Institute of Cornwall.—"Journal." Nos. 16, 17. October, 1874; September, 1875. From the Council.
8. Liverpool Geological Society.—"Proceedings." Part III. Vol. 1. 1874-5. From the Council.
9. Philosophical Society of Manchester.—"Proceedings for 1874-5." Catalogue of the Library. 1875. From the Council.
10. Natural History Society of Glasgow.—"Proceedings." Part I. Vol. 2. From the Council.
11. Warwickshire Naturalists Field Club.—"Proceedings for 1874-5." From the Club.
12. Bristol Naturalists' Society.—"Proceedings for 1868, 1869-70-1." Vols. 3 to 6, and New Series. Part II. Vol. 1. 1874-5.—"Laws." 1875. From the Society.

13. Walford Natural History Society.—"Transactions." Parts I., II. Vol. 1. 1875. From the Council.
14. Leeds Philosophical Society.—"Report for 1874-5." From the Council.
15. North Staffordshire Naturalists' Field Club.—"Annual Report." 1875. From the Club.
16. Leicester Literary and Philosophical Society.—Two "Reports for 1875." From the Council.
17. Exeter Museum and Free Library.—"Report for 1875." From the Committee.
18. Birmingham Free Library.—"Report for 1874." From the Committee.
19. Williamson (Professor W. C.)—"Memoir, from the Philosophical Transactions, On the Fossil Plants of the Coal Measures." Parts I. to VI. 4to. From the Author.
20. Ricketts (Chas., M.D.)—"Sections of Strata at Huyton, near Liverpool;" and "On the Metamorphic Rocks of Malvern." From the Author.
21. Heywood (James, F.R.S.)—Three Plates of the Fossil Trees at Dixon Fold, near Bolton. From Mr. Heywood.
22. Read (T. M.)—Papers on "Glacial Geology." From the Author.
23. The "Owens College Calendar for 1875." From Principal Greenwood.
24. Mackenzie John.—Reports for 1873-4, upon the Coal-fields of New South Wales. Map and sections, folio.

FROM THE UNITED STATES.

1. Smithsonian Institution, U.S.A.—"Reports of the Commissioners of Agriculture for 1873-4." Ryl. 8vo. 2 vols.
2. Warren (G. K.)—"Physical Features in the Valley of the Minnesota River. Part II., pp. 22.

19. Winchell (N. H.)—"On the Hamilton in Ohio." pp. 4.
20. Winchell (N. H.)—"Geological and Natural History Survey of Minnesota." 2nd Annual Report. 1873. pp. 220.
21. Hayden (F. V.)—"Map of the Upper Geyser Basin, on the Upper Madison River, Montana." Scale, 6 in. to 1 mile. By G. R. Bechler. 20 in. by 18 in., tinted.
22. Hayden (F. V.)—"Map of the Lower Geyser Basin." Scale, 6 in. to 1 mile. 34 in. by 21 in., tinted.
23. Hayden (F. V.)—"Physical Map of the Sources of the Snake River, &c." tinted. Scale, 5 miles to 1 in.; 26 in. square.
24. Ditto. Geologically coloured. Same scale and size.
25. Hayden (F. V.)—"Geological Map of Montana and Wyoming Territories." Scale, 4 miles to 1 in. 29 in. by 21 in.
26. Hayden (F. V.)—"Preliminary Map (Physical) of Central Colorado, as Surveyed in 1873-4." Scale, 10 miles to 1 in. 25 in. by 22 in.

FROM SWEDEN AND FRANCE.

From the Royal University of Christiania.

1. Sexe (S. A.)—"On Giants' Caldrons (Ice-worn Holes on Rocky Surfaces.") 4to. pp. 44. Plates. 1874. *English and Norsk.*
2. Kjerulf (Professor T.)—"On Polished Rocks by Glacier Action (om Skuringsmærker, etc.)" Part II. 1872. 4to. pp. 92. Woodcuts of Fossils of Stage 1 (Cambrian) and Sections. *French and Norsk.* 1873.
3. Tromso Amts Orografi (Terraces of Tromsœ Sound). 8vo. pp. 181-240. *Norsk.*
4. Pettersen (Karl).—"On the Quarternary Period on the Isle of Tromsœ." 8vo. pp. 103-176.
5. Schiœtz (O. L.)—"Undersœgelser over Sparagmit-Kvartz-Fjeldet." (Geology about Hamer Stipt). 8vo. p. 100. 1873. *Norsk.*

6 Schiœtz (O. E.)—"Analyse of Xenotim (Phos of Yttrium)." p. 13. 8vo. *Norsk.*

7. Helland (Amund).—"Om Kromjersten i Serpentus." 8vo. p. 20. 1873.

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8. "Societe Khediviale de Geographie Discours au Caire (Cairo) A'La Seance D'Inauguration." 2 Juin. 1875.

9. "Bulletin de la Societe Vaudoise des Sciences Naturelles." Vol. 13. No. 74. 1875.

BOOKS PURCHASED IN 1875.

Agricola—"De Re Metallica." Folio. 1657.

Agassiz—"The Glaciers of Switzerland." Folio, plates.

Bailey (W. H.)—"Figures of Characteristic Fossils." Vol. 1. Palæozoic. 1875.

Brongniart—"History of Vegetable Fossils." 2 vols. 4to.

Burat (Amedee)—"Treatise and Atlas on Coal Mining." Folio.

Combes (M., Ch.)—"Treatise and Atlas on Coal Mining." Folio

Cotta (B. Von)—"Rocks, Clasified." 1866.

Falconer (Hugh)—"Memoirs," &c. 2 vols. 1868.

Geikie (James)—"The Great Ice Age." 1874.

Geikie (Archibald)—"Life of Sir R. Murchison." 2 vols. 1875.

Geological Magazine. 1875.

Geological Survey Maps of the North-West Counties. 40 Maps, and Memoir of the Burnley Coal Field.

Mammatt (E.)—"Coal Plants of the Ashly-de-la-Zouch Coal Field." 4to.

Phillips (John)—"Geology of Oxford and the Valley of the Thames." 1871.

Phillips (John)—"Vesuvius."

Phillips (John)—"Geology of Yorkshire." New edition. 4to. 1875.

Phillips (J, A.)—"Elements of Metallurgy." 1874.

Palmieri (Prof.)—"The Eruption of Vesuvius in 1872-1873."

Societies with whom the Society Exchanges its Transactions, and Institutions and Journals to whom a Copy is sent Free.

I.—England.

London.....	British Museum.
	Geological Survey.
	Geological Society.
	Geologists' Association.
	Royal Institution.
	Royal Society.
Manchester	The Owens College.
	Literary and Philosophical Society.
	Free Library, Camp Field.
	Scientific Students' Association.
	Salford Royal Museum.
Liverpool.....	Geological Society.
	Free Library and Museum.
Leeds	Geological and Polytechnic Society.
	Free Library.
	Philosophical and Literary Society.
Leicester.....	Literary and Philosophical Society.
Birmingham	Free Library and Museum.
Cambridge	Geological Museum, University.
Oxford.....	Geological Museum, University.
Exeter.....	Albert Museum, and Library.
Cornwall	Royal Geological Society, Penzance.
	Royal Institute, Truro.
Truro	Miners' Association of Cornwall and Devon.
Bristol.....	Naturalists' Society.
Warwick.....	Natural History Society.
Swansea	South Wales Institute of Engineers.
Barnsley.....	Midland Institute of Mining Engineers.
Dudley.....	Geological and Scientific Instiute.
Newcastle-on-Tyne..	Institute of Mining Engineers.
Sheffield	Free Library and Museum.
South Shields	Public Free Library.

II.—Scotland.

Edinburgh	Geological Society.
	Royal Society.
	Royal Physical Society.
Glasgow	Geological Society.
	Natural History Society.
Dundee	Free Library and Museum.

III.—Ireland.

Dublin.....	Royal Dublin Society.
	Royal Geological Society of Ireland.
Belfast.....	Natural History Society.

IV.—Foreign Societies.

Berlin.....	Geological Society of Germany.
Calcutta	Geological Survey of India (Dr. Oldham).
Christiania	Royal University of Norway.
Dresden	Natural History Society "Isis"
Lausanne (*Suisse*). .	Societie Vaudoise des Sciences Naturelles.
Paris	Societie Geologique.
St. Petersburgh ..	Academy Imperial.
Turin	Academie Royale.

V.—United States and Canada.

Montreal	Geological Survey of Canada (A. R. C. Selwyn, F.G.S., Director).
	McGill College (Principal J. W. Dawson)
Albany, U.S.	Verplanck Colvin.
Boston, U.S.	Free Library.
Easton, U.S......	American Institute of Mining Engineers.
Indiana, U.S.	E. C. Cox.
New Haven, U.S...	Professor O. C. Marsh, F.G.S.
New York, U.S...	*Silliman's Journal.*
St. Louis, U.S. ..	G. C. Broadhead, State Geologist.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART II. VOL. XIV. SESSION 1875-6.

At the ORDINARY MEETING of the Society, held on Tuesday, 30th November, 1875.

Mr. JOSEPH DICKINSON (Vice-President), F.G.S., H.M. Inspector of Mines, in the Chair.

'STIGMARIA FICOIDES" IN THE COAL OF LEINSTER, IRELAND.

The CHAIRMAN said that, a few weeks ago, a member of the Society (Mr. Binney) enquired of him whether, underneath the coal seams of Kilkenny and Queen's County (Leinster coal-field) any trace was found of the *Stigmaria ficoides*—that was the rootlets—or whether the means by which the coal had been converted into anthracite had destroyed them. As the question might be interesting to other members, he had brought some of the fire-clay which underlay the seams in question, showing that the rootlets were as plain to be seen in the floor of some of the seams as in our English seams.

The specimens were exhibited and described; and Professor DAWKINS said he had observed in the under clay of Pembrokeshire—which was, he supposed, of the same relative antiquity as that of Leinster—rootlets of *stigmaria;* but anything like one of the specimens now shown (a granite-like rock) he had never seen. In that specimen felspar,

mica, and quartz were perfectly shown. A specimen of crushed clay, which was exhibited, was very interesting, as showing the enormous pressure to which it had been subjected.

The CHAIRMAN explained that the granite-like specimen was taken from underneath the fireclay that lies below the deep coal seam at Clogh Colliery, Castlecomer.

AGE OF THE NEW SOUTH WALES COAL BEDS.

Professor BOYD DAWKINS said that, with regard to the age of the coal-fields it might, perhaps, be of interest for him to say that when in New South Wales he had an opportunity of critically examining the coal fields of that colony, and there could be no doubt as to its geological age; for, in its lower portion, there were marine fossils, very much after the same fashion as we have in our own coal field of Lancashire. Above this, in the coal measures proper, there are *lepidodendron*, *calamites*, and *sigillaria*, associated with some peculiar ferns known as *Glossopteris*. Up to the present time the age of that coal field had been in dispute between the Rev. W. G. Clarke on the one hand, and Professor McCoy on the other; and it appeared that Professor McCoy had only argued from the fern alluded to, which occurs in the lower mesozoic strata of India. But, certainly, when we take into consideration the marine fauna—the shells living in the sea of the lower carboniferous strata—and the terrestrial vegetation, which was to a large extent identical with that in our own coal field, there was not much doubt as to the New South Wales coal being Palæozoic.

The CHAIRMAN: Is it identical with our carboniferous age?

Professor DAWKINS: I don't say that; but it contains the

same fossils, and therefore we must classify it with the same group.

The CHAIRMAN said he received, by the last Australian mail, copies of the reports of the Inspectors of Mines in New South Wales for the last year. The mines appeared to be in a very efficient state, but he had not had time, as yet, to compare the results as to accidents with the quantity of coal got.

At the ORDINARY MEETING of the Society, held on Tuesday, 21st December, 1875,

Mr. JOHN AITKEN, Vice-President, F.G.S., in the Chair.

Mr. John Higson, Manchester, and Mr. Joseph Thompson, Norley Colliery, Wigan, were duly elected Ordinary Members of the Society.

The following Presents to the Library were announced by Mr. FORBES, Hon. Secretary:—

JOURNALS, &C., FROM THE SOCIETIES:—

1. Geological Society of London.—Abstracts of Proceedings, 1875-6.
2. Geologist's Association.—Proceedings No. 5, Vol. IV.
3. South Wales Institute of Engineers.—No. 4, Vol. IX.
4. Journal of the Royal Institution of Cornwall.—Nos. 16 and 17.
5. North Staffordshire Naturalist's Field Club.—Report, 1875.
6. Journal of the Royal Geological Society of Ireland.—Part 2, Vol. IV.
7. Proceedings of the Royal Physical Society of Edinburgh, 1874-5.
8. Dundee Free Library Report, 1875.
9. Dresden Natural History Society,—"Isis." Part 1, 1875.
10. Tuscan Natural History Society.—Vol. I., Parts 1 and 2.

FROM THE AUTHORS:—

Carboniferous Flora, Part 4. "Sigillaria and Stigmaria." By E. W. Binney, F.R.S., F.G.S.

On the Relative Age of Post-Glacial Deposits in the North and South of England. By C. E. De Rance, F.G.S.

Cause of the Glacial Period. By Dr. C. Ricketts, F.G.S.

Royal Society of New South Wales.—Address by Rev. W. B. Clarke, M.A., F.G.S.

Palæontology of the Carboniferous Strata, West of Scotland, with Vertical Sections. By Dr. Hunter. Parts 1 and 2. 1875.

FROM Mr. W. J. GRIMSHAW:—

The Coal Viewer and Engine Builder. By John Curr, of Sheffield. 1797.

COLVIN, VERPLANCK:—

Topographical Survey of the Adirondack Wilderness of New York. Report for the Year 1873-4. 8vo.

First Annual Report of the State Parks of New York. 1874. pp. 22.

HAYDEN, F. V.:—

United States Geological and Geographical Survey of Colorado. 1873. 8vo.

United States Geological Survey of Nebraska. Final Report. 1872. 8vo.

United States Geological Survey of Montana and adjacent Territories. 1870-1. Two Vols. 8vo.

Bulletin of the United States Geological and Geographical Survey of the Territories. No. 5. Second Series. 1874-5.

Catalogue of Publications of the United States Geological Survey, 1874. pp. 20.

Catalogue of Photographs of the United States Geological Survey, 1874. pp. 83.

List of Elevations West of the Mississippi. 1875. pp. 82.

Meteorological Observations in Colorado and Montana Territories, 1873-4. By G. B. Chittenden. pp. 57.

ON MEASURING AIR IN MINES.

By Joseph Dickinson, F.G.S.,
H. M. Inspector of Mines.

Anemometers, or air-meters, as they are often called, are now in common use for measuring the velocity of air currents in mines. Forty years ago they were seldom seen. The methods then practised are described in the well-known report prepared by Mr. James Mather, Honorary Secretary of the South Shields Committee appointed in the year 1839 to investigate accidents in mines. They were by the smoke of gunpowder or tobacco, and the regulated pace of a person by the flame of a candle. No mechanical appliance appears to have been in use. The report refers to an anemometer constructed by Mr. Thomas Elliot, (a brother of the present baronet, Sir George,) in 1835, when an overman of Pensher Colliery, which worked by "the air acting on four wands similar to a windmill, which met so strongly with the approval of the coal owners that in that year, at their meeting at Newcastle-on-Tyne, they presented him with ten guineas for his invention, *but they did not adopt it in one of their mines.*"

The first anemometers which appear to have come into general use in mines were those of M. Charles Combes, of Paris, and Mr. Benjamin Biram, of Wentworth, Yorkshire, both being similar in principle to Mr. Elliot's. Mr. Combes, in his valuable work, "Traité de l'Exploitation des Mines, 1844," refers to a description of his anemometer written by him in the "Annales des Mines," by which it appears that his anemometer was introduced in 1837. Mr. Biram's anemometer, it seems by the patent specification, was sealed 3rd August, 1842, the scope of it being for registering the velocity of bodies propelled through water or wind and employment for paddle wheels, stern propellers, and other rotary engines." M. Combes' instruments seem to have

been made by M. Newman, of Paris, and Mr. Biram's by Mr. Davis, of Derby.

Robinson's anemometer, consisting of four revolving hemispherical hollow cups fixed on four arms radiating from a centre (as commonly used on observatories), have as yet been but little used in mines. It appears by F. Pastorelli & Co.'s work on standard instruments, and by other authorities, that this anemometer was invented by Dr. Robinson, of Armagh, and that it was used in tidal and meteorological observations on the coast of Ireland in 1850. It is also stated that Dr. Robinson, after a series of carefully conducted experiments, found that these cups fixed upon a vertical axis travel at the rate of one-third of that of the wind, and that this law exists irrespectively of the size of the cups or the length of the arms.

Another combination of the windmill anemometer has recently come into use in mines. The arrangement is attributed to Dr. Parkes, F.R.S. for whom it is said to have been originally made by Mr. Lowndes, a working instrument maker in London. This instrument is sometimes known as the Cassela or Casartelli anemometer.

All windmill anemometers, it will be understood, require timing, and also correction, in order to ascertain the true velocity of the air from the number of revolutions.

Anemometers, "a mere inspection of which would enable an officer to ascertain in an instant the exact velocity of the air, without the necessity of timing or correcting," have long been known, but the only one that I know of as being in use in mines, is the one devised by myself about twenty-five years ago, which is known as the Dickinson anemometer. By means of this the velocity of the air may be read off at a glance. It consists of a light, counterpoised, flat fan-plate, which is usually made of talc, and hung upon two fine bearings, so as to be easily moved by the air current.

Alongside of the fan-plate there is a quadrant, graduated and figured—the figure up to which the fan-plate is blown being the velocity of the air, in feet, per minute. There is also a spirit level, for setting the instrument level. In using this instrument all that is requisite to ascertain the number of cubic feet of air passing per minute is to multiply the velocity indicated by the anemometer into the area in feet of the place where the observation is taken. These anemometers have been made only by Mr. Casartelli, of Manchester.

A modification of the Dickinson anemometer, which I have seen permanently fixed in the Bardsley Colliery, Ashton-under-Lyne, by Mr. George Wild, has the counterpoise made of a balance weight, which is worked by a chain over a pulley. For a fixture, like this, the chain and weight conterpoise appears to be an improvement, as the friction of the links of the chain over the pulley imparts steadiness to the fan-plate, and thus enables the average velocity to be better read in intermitting currents.

About the same time as the introduction of the Dickinson anemometer, Mr. John Phillips, of Cornwall, devised a similar instrument, except that, as I understand, it had no counterpoise.

M. Devillez has also introduced one on the same principle, but with a hollow cylindrical cup instead of the fan-plate.

Another, with a flat plate suspended by two rods, by Dr. Prestell, is described by Messrs. Negretti and Zambra, of London, in their illustrated catalogue for 1873.

Mr. William Peace, of Wigan, also patented an anemometer about twenty years ago, the moving power being from the action of air on a block of wood hung in the downcast shaft, from which, by means of a wire or cord, motion is given to a finger on a dial plate above ground.

The foregoing anemometers are apparently the principal

ones which have as yet been proposed for or actually used in mines. A variety of others, however, some of ancient date, have been used for measuring the wind on the surface.

The first anemometer of which there appears to be any record is attributed to Dr. Croune, in 1667, which, it is said, did not answer the purpose intended. Better instruments seem to have been invented by other scientific men during the last century. The modes of action comprised the compression of a spiral spring, the elevation of a weight round a centre acting at the arm of a variable lever, a bag of air communicating with a glass tube, in the form of a lengthened U, being sometimes substituted for the spring. An anemometer by Leslie depended on the principle that the cooling power of a current of air is equal to its velocity. Another instrument depended upon the evaporation of water, the quantity evaporated being proportional to the velocity of the wind, varying, however, one would suppose, according to the dryness of the wind.

Wolfius's anemometer, as described by him in 1746, consisted of four sails similar to those of a windmill, but smaller, turning on an axis. On the axis is a perpetual screw, which turns a vertical cog-wheel round a second axis. To the second axis is attached a bar on which a weight is fixed, so that the sails cannot turn without moving round the bar in a vertical circle. When the wind acts upon the sails the bar rises, and this continues until the increased leverage of the weight furnishes a counterpoise to the moving force of the wind. It also appears to have acted by winding up a weight.

Regnier's anemometer indicated the pressure upon a dial plate, the moving power being a flat wooden surface on which the air acted, pressing it into a box with springs and mechanism.

The anemometers of Dr. Whewell and Mr. Osler are

described in Sir W. Snow Harris's report to the British Association in 1841-44. That of Dr. Whewell was by means of a windmill fly, which worked an intermediate train of wheels and caused the varying pressure to be marked on a fixed cylinder. Mr. Osler's traced the direction of the wind and its pressure on a given area, which was moved by clock mechanism. An invention by the Rev. W. Foster is also described as ingenious.

Lind's anemometer, which is an inverted glass syphon in the form of a U, is described in the Philosophical Transactions, 1775. An improvement of this has been made by Sir W. Snow Harris, who, by reducing one of the limbs to the diameter of one-fourth of the tube which is open to the wind, and by making the first part of the scale horizontal, has greatly increased the delicacy of the instrument. He also put a plumb on it, and a light vane, to facilitate observation.

As a water-gauge, or manometer, the inverted glass syphon, known as Lind's anemometer, is identical with what is now commonly used in mines for measuring the pressure of air. The water-gauge introduced a few years ago by Mr. John Daglish, formerly of Hetton Colliery, Durham, is on the same principle.

M. E. Péclet, in his valuable "*Traité de la Chaleur*, Paris, 1860," says, that in 1820, M. Kallsténius employed a mill, with twelve wands, to measure the force of the air, and he decribes M. Combes' anemometer. He also refers to a novel one by M. Morin, somewhat the same as M. Combes'. Also to the apparatus of M. Van Hecke, by which the ventilation is registered. Likewise to other instruments; in one instance, by means of the air acting upon the surface of a body attached to one end of an arm working over a centre, there being a pointer at the other end of the arm, which indicates the force on a dial; and in another instance, by

the air acting upon hollow cylindrical cups hung in the current, by which a finger is worked on a dial plate. He also describes various water-gauges, both for ordinary and for great precision, including, amongst the latter, one having one of the limbs inclined.

These are apparently the principal anemometers which have as yet been introduced, either above or below ground. It is possible, however, that others may have been used, and even that some of them may have been invented by other persons than those whose names they now bear. Indeed, looking at the instruments generally, there is little more of any principle in them beyond what appears either in the windmill, or what may be exemplified by a light substance hung from a cord.

With such a wide choice of anemometers, let it not, however, be supposed that there is no difficulty in ascertaining the true average velocity of some air currents. It is only when the current is regular that implicit reliance may be placed upon such instruments. In an intermitting current the pulsations are shown plainly enough by either the counterpoised fan-plate of the Dickinson anemometer or the pendant of other similar instruments, and in reading off the velocity from such the average of the vibrations must be taken. But with the windmill anemometers the altered speeds are more difficult to detect, and they are also accompanied by the serious defect that when the intermittance is great the number of revolutions recorded are so largely in excess as to be practically useless, owing to the momentum which the wheel attains, when the current is quick, carrying it (especially when the wheel is a heavy one,) with but slightly lessened speed through the periods when the current is slow.

This exaggeration of the revolutions of wheel anemometers in intermitting currents may be readily proved, either by

watching the instrument when blown upon in puffs, or by passing it intermittingly over any given distance in a still atmosphere. It may also be proved by placing the instrument in an intermitting current, when the actual average velocity can be accurately known, as in those cases where the total quantity of air passing is known by having to pass through an air pump of certain dimensions, and making a certain number of strokes per minute. When furnaces or fans are used as the ventilating power, the intermittance is generally not of much importance, except when air doors are opened and such like, or when firing up the furnace, or if there be some irregularity in the construction or working of the fan. But with a single air pump, worked with one piston, or if there be two pumps and two pistons, but changing stroke at the same time, the effect upon the anemometer, caused by the intermitting current, is such that the revolutions are enormously increased. The intermittance is even perceptible, and affects the anemometer when there are two pumps, one of which changes stroke when the other is at half stroke, but this greatly lessens the injurious effect, and the current is comparatively steady.

Similarly exaggerated results also occur with the windmill anemometers when they are changed about at short intervals, as is not uncommon, in endeavouring to get an average velocity of the current in the various parts of the space where the observation is being taken. In these instances the momentum attained in the quick part of the current carries the wheel round at a higher velocity than it would have attained in those parts where the current is slow.

Inaccuracy in this latter respect may, however, be avoided by having separate anemometers placed at the same time in each part of the airway space where the velocity varies, and averaging the results. When, however, only one anemometer is used for measuring a current which varies at dif-

instruments. For making the correction in this way, the numbers to be added are sometimes given in a tabular form, and sometimes in the form of a diagram, from which the number has to be measured by a scale. The correction, as before stated, varies with each anemometer; but with Biram anemometers of like construction, and registering revolutions without any attempted correction in the instrument, the required addition for corecction does not vary much, and it would appear that, with instruments so constructed, the correcting number to be added diminishes as the velocity increases, the number being often small when the revolutions exceed 400 per minute. The ratio of correction appearing, generally, like the asymptote of the hyperbola, always approaching, but never meeting.

From these sources of error in the measurement of air currents in mines many mistakes have apparently been made in the amounts of ventilation, and when the result has been used for determining the amount of power utilized by ventilating machines, the percentage has been greatly exaggerated.

For comparative observations of the ventilation made from time to time in a mine, the surest way is to place the same anemometer on the same spot, and under the same circumstances, on each occasion relying upon revolutions and not velocity.

But for ascertaining the actual quantity of air passing in a mine when the current is intermitting—so difficult, indeed almost insurmountable, is the process with an anemometer—that, where open lights are allowed, it seems preferable (although it has been called a barbarous way) to resort to the old rough and ready ways, by the smoke of gunpowder or tobacco, or by the flame of a candle, as previously described; and where gunpowder, smoking, and open lights are prohibited, a small balloon filled with gas, to float in the

air and bound about from roof to floor and side to side, as carried by the air current is a good substitute.

For steady currents, however, there is nothing so good as an anemometer. The candle cannot be carried with the average of the whole current, and the smoke of powder or tobacco is found to hang where the current is slow, making it at times uncertain what portion of the arrival should be taken as indicating the average.

Similarly erroneous computations of the per centage of power utilized by ventilating machines have likewise been made, when, in intermitting currents, the pressure of air (which is one factor in the calculation,) has been taken by the common inverted glass syphon water-gauge. Notwithstanding that in nearly all such gauges the tube is usually contracted at the bend, the water dances up and down so that it is impossible to read off accurately the average distance between the two surfaces.

The want of a compensating water-gauge for measuring the pressure of intermitting currents first presented itself to me in the year 1861, when measuring the amount of power utilized by the Struvé 'air-pumps. On that occasion, finding it impossible to obtain any reliable measure of the average pressure of air by the ordinary water-gauge, my colleagues, Mr. Thomas Evans, and the late Mr. John Job Atkinson, and myself, used two ordinary buckets of water, one bucket being placed outside and the other in the return air, the water in each being connected by an India rubber tube. This method served the purpose, but as the buckets widened towards the top, the area of the surface of water in each was not equal, and consequently the depression of water in one did not correspond exactly with the elevation in the other, which made it requisite to measure the height it rose in one and the depth it fell in the other, and to add the two together in order to obtain the total pressure. A readier mode than

the buckets of water, as might be expected, soon occurred to us, and in the same year I had a proper compensating water-guage, made by Mr. Casartelli, of Manchester, (the one here shown to the meeting,) by which, no matter how intermitting the current, an accurate measure of the pressure may be readily taken, by having the two limbs for the water so large and the connecting aperture at the bottom so small that the flow of water does not sensibly affect the level during the pulsations. The gauge consists of a brass box, divided by a thin partition into two chambers, with glass front, and with the aperture at the bottom connecting the water in the two chambers regulated by a tap. The full size of the gauge is 6 inches high, 4in. broad, and 3in. wide; the 4 inches in breadth being divided by the partition, making the two chambers each 2 by 3 by 6 inches. The tap for regulating the flow of water between the two chambers is worked outside, underneath the bottom of the gauge. At the top of one of the chambers there is an opening one inch in area to admit the pressure of air on that side, and at the top of the other chamber there is a brass nozzle for inserting through an augur hole to admit the pressure of air at the other side. There is also a tap on this nozzle for closing when required. At each side of the glass front, and also down the middle of it in front of the partition dividing the two chambers, there are scales graduated into inches and tenths, so that the difference between the level of the water in the two chambers may be accurately seen. Mr. Atkinson soon afterwards had also a gauge of the same kind made for himself, but his had a pipe which came outside for connecting the two chambers at the bottom, instead of a tap regulating the size of a hole in the partition, as in mine. These two compensating water-guages were probably the first of the kind used in this country; but on afterwards using them in testing some of the ventilating machines in

Belgium, we were informed that similar gauges had been previously used by the ingenious mining engineers in that country.

The CHAIRMAN said he was glad to find, from the large attendance of gentlemen interested in collieries, that the subject brought under their notice by Mr. Dickinson was thoroughly appreciated. He knew of no subject which could be of greater interest or importance, at the present moment, than that relating to the ventilation of mines, and the contrivance of means whereby the safety of workers could be ensured, and the calamitous explosions, which of late had been of too frequent occurrence, might be prevented.

On the motion of Mr. WILD, seconded by Mr. P. PICKUP, a vote of thanks was passed to Mr. Dickinson for his paper.

The CHAIRMAN having intimated that the subject was open for discussion.

Mr. J. THOMPSON (Norley Colliery,) said that every one must have been pleased with Mr. Dickinson's treatment of the subject; but he (Mr. Thompson) must say, in reference to "standard anemometers," that he did not think there was a standard anemometer in existence. There were no reliable data on which to certify the accuracy of any instrument. In the second place, he did not know that it was possible accurately to measure the velocity of the air current in any air way, even supposing there was a standard anemometer in use, on account of variations in the movement of the current along the goaf. He mentioned these points for the purpose of eliciting discussion.

Mr. HERBERT FLETCHER said it was not of so much consequence that they should know the exact quantity of air circulating through a mine, as it was that they should ascertain the variations occurring from time to time.

Mr. JACOB HIGSON said there must be some data, as for instance a calculation of the rate at which powder smoke

would travel, or of the rate at which any moveable body in an atmosphere in agitation would move, before they could construct an instrument for measuring the air current. There might, it was true, be no standard anemometer, but it did not follow that there were not laws by which they were to be governed, and no standpoints from which to work in the construction of those standards; and, if he gathered the tenour of Mr. Dickinson's paper aright, his (Mr. Dickson's) object was to turn people's attention to this subject, with a view to the determination of some standard, or broad principle, which should guide them in the construction of anemometers. One thing mentioned by Mr. Dickinson had struck him—the use of small air balloons. Mr. Dickinson had stated that the balloons, attached to a string, in an air-way, would sometimes rise to the roof, then the sides, and often strike the floor. In calculating the distance travelled by an air balloon in a given time, it was clear that unless they took the angles from roof to floor, and from floor to sides, they would not get at a correct calculation. That was the only point in the paper on which he was disposed to offer any divergence of opinion.

Mr. W. H. J. Traice said it occurred to him that if they had no standard anemometer, they had at any rate the plan of testing the accuracy of such an instrument, which he (Mr. Traice) knew was used by Mr. Daglish, Mr. Atkinson, and others. Assuming that air, in motion, infringing upon any surface at a certain speed had the same effect as if a body was moved against the air, if that could be accepted as absolutely true, theoretically and practically, there was no doubt whatever that the moving an anemometer against the air, at the end of a radial arm—supposing that all proper means were taken to provide uniformity of movement—did at any rate enable them to get a standard measurement, or standard mode of testing an instrument, and that, if it

were possible to have all instruments tested by apparatus of that kind, would be a very good starting point towards getting a standard anemometer, he was of opinion that the Dickinson anemometer, as a means of indicating sudden changes in the velocity of the air current, would be an admirable cheque upon the Biram instruments. But we could not avoid calling attention, in reference to the prevailing error in the Biram group of anemometers,—the continuance of the movement, after the immediate effect had been registered—that it was not important in estimatiug the quantity of air passing through a mine. The obstruction of the air way by the body of the observer was, moreover, not sufficiently taken into account. With reference to Mr. Fletcher's remark, he supposed that practical men would admit the possibility of ascertaining the sufficiency of air in a mine, without, by means of an anemometer, measuring the exact quantity. But the law required that there should be a proper quantity of air, and that the air should be measured, in order that, in the event of accident, the precise quantity passing through in a given time might be known. Hence the best means of curing an evil is getting to thoroughly understand its nature and dimensions.

Mr. JOHN HIGSON said he had often found, in measuring the velocity of air currents, that the Biram anemometer, owing to friction, did not register so much as the Dickinson instrument. Extended over a period of time, however, it was possible that the Biram might give almost, if not quite, as accurate a measurement of wind as the Dickinson.

Mr. THOMPSON (to Mr. Dickinson): Will you be good enough to state what your anemometer is graduated to?

Mr. DICKINSON: You may have it graduated to what you like by regulating the weight of the fan plate and the counterpoise, but there is a limit up to which the whirling machine can be used for setting the instrument by. For

instance, you cannot whirl the machine round beyond certain speeds; therefore, so far as the instrument can be graduated by the whirling machine, it does not go up to perhaps more than 700 feet per minute.

Mr. THOMPSON: It struck me that, possibly, the fan, under a high velocity, might be thrown outside the graduation.

Mr. DICKINSON: Certainly it would be, if the speed were quicker than the instrument was made to register.

Mr. JOHN HIGSON: It is frequently the case with the ordinary anemometer.

Mr. THOMPSON: That instrument is graduated to 700 feet.

Mr. DICKINSON: It is; but you will not find two alike. Each instrument is set upon its own merits, and graduated upon the whirling machine, or set by one which has been so graduated, by actual experiment; so that, whatever variation there may be in the weight of the fan plate on the counterpoise is corrected by the height to which the fan plate is blown whilst the instrument is being graduated. The usual way with these anemometers is to have them set at what is a convenient average. You may not always find it absolutely necessary to measure the current of air where the velocity is 1,200 feet per minute. If you take the Biram anemometer and put it in a current of 1,200 feet per minute, it may, like the one I now show you, be blown to pieces. That is how this instrument was broken—placing it in a current too great for the instrument to bear. Moreover, in an air current of over 1,000 feet per minute you scarcely get either lamp or candle to burn. Nearly all the currents we have to deal with in mines are under that figure; so, if that instrument was registered up to 700, you would probably find, in some part of the air way, the current sufficiently reduced to render that applicable.

Mr. Herbert Fletcher said that the first anemometer shown to the meeting by Mr. Dickinson, (the Cassela or Cassartelli Biram), would stand a very strong current of air. He had known them to indicate velocities of over 2,000 feet per minute without showing any sign of deterioration. One advantage of the whirling machine over the fan, was that the observer could hold it further from his body. The fan, on the other hand, required minute inspection, and the placing of a lamp—giving, if a safety lamp, but a dim light—close to it during the observation. For his own use, he preferred the whirling machine, and he wished to know if Mr. Dickinson did not think that the liability to error, arising from the generation of momentum had not been rather overstated, and whether passing that instrument through currents of varying velocities, the speed which had failed to be obtained during the time of its passage from the slower into the stronger current, was not counterpoised by the velocity failed to be lost in passing from the stronger current to the slower? Of course, the machine did not change its velocity as quickly as the current in which it was placed. In support of his preference for the Biram instrument, he would say that in the collieries with which he was connected, measurements were taken on a larger scale, very frequently, both in the return and intake air-wags in a manner the correspondence of which gave great satisfaction, and enabled great faith to be placed in the correctness of the observations. He had got Mr. Casartelli to construct an instrument, with a dial to be placed on the outer wall of the cupola, or upcast pit, by which the velocity of the air current could be read. (One of these instruments, Robinson's cups, he exhibited to the meeting.)

Mr, John Higson said that, of course, all air currents fluctuated, or varied, but with a fan constructed on sound principles, or with a furnace of ordinary construction, the

variations in a well-conducted mine would not be very great. He found, in practice, that the Dickinson anemometer registered a larger amount through any given space of time than the Biram. That had been usually and generally the case, and it seemed to him that the question of friction, in the Biram instrument, was overlooked. If not, he would like to hear from Mr. Dickinson how it was to be accounted for.

Mr. DICKINSON said that the points which Mr. John Higson and others had referred to in the debate, were explained in his paper. He had given the formula which had been in existence since M. Coombes wrote his book, in 1844, and which was still in use except that, in this country they sometimes changed the letters—which meant nothing—and he had also explained that, before they could ascertain the actual velocity of air by any windmill anemometer, they must either use that formula for correcting the revolutions into velocity, or they must use an addition of some kind either by figures, arrived at by testing the instrument on a whirling machine ; or they must measure the desired number from a diagram which represented the addition that was required for the anemometer in hand. Each windmill anemometer required a different table of correction for itself; but that there was no standard anemometer for steady currents, as Mr. Thompson supposed, was, he thought, a pure fancy. They could get, with the present whirling machine, a standard anemometer almost theoretically correct. The only error that could be detected was the difference between an instrument being presented with its flat surface to the wind, and the fact that, in the whirling machine, they had to whirl it round in a circle, so that at all times the front was not exactly presented to the air. With that little error, anemometers might be, and were, set; and the whirling machine now, by means of a weight, could be made to move with all the steadiness of a clock ; so that when an instru-

ment like the Dickinson anemometer was put upon it, and whirled round, with the weight loaded to a certain degree, it worked as steadily as if fixed in a regular current. Mr. Jacob Higson had made some remarks upon the use of small air balloons. He (Mr. Dickinson) thought it would give an exaggerated measurement if they took the zigzag direction in which a balloon travelled in an air course. The current, as many of us knew, was not always straight along the air course; the balloon would naturally follow the direction which the air took; and in an intermitting current would give as accurate a measurement as it was possible to obtain.

The CHAIRMAN suggested, as a means of making the Biram instrument effective in intermittent currents, the employment of a delicate spring, sufficient to overcome the momentum.

Mr. SMETHURST mentioned a contrivance of his own for testing the principle of the Biram and Dickinson anemometers, the main features of which were the use of governor balls for regulating speed in intermittent currents, and the self-registration of results by means of a pencil upon paper.

Mr. GARFORTH having offered some observations,

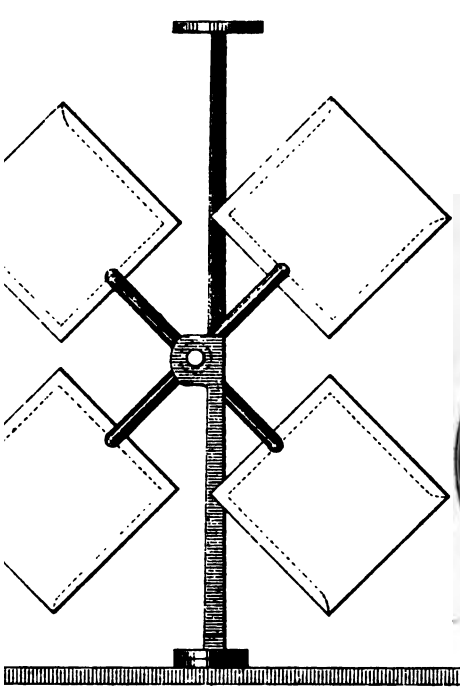
Mr. DICKINSON, in closing the discussion, said that in his paper he had not expressed a preference for one anemometer over another. He had simply given the meeting a description of each one that he knew of, and mentioned the sources of error to which they were liable. The liability to error was clearly pointed out, in his paper, of all the mill machines, including Robinson's cups. There was not an anemometer of that description in use that was not liable to the objection of which he had spoken: the momentum carried it over the slow speeds, and a record was not furnished of the average velocity of the air. He preferred, for general purposes, the Dickinson anemometer, on account of the expedition with which observations might be made by it.

At the ORDINARY MEETING of the Members, held at the House of the Literary and Philosophical Society, George Street, on Tuesday, 25th January, 1876.

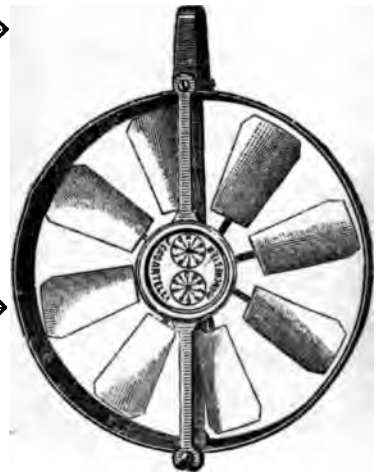
Mr. J. DICKINSON, V.P., F.G.S., H.M. Inspector of Mines, in the Chair.

The CHAIRMAN said that the society was becoming possessed of a large number of valuable books; the only drawback was, that they were short of room for book cases to put them in: the books were not taken out of the library, and read, by as many of the members as one might suppose would be wishful to avail themselves of such opportunities. He supposed the members were all aware that they might take books home to read.

Mr. PLANT said that the catalogue informed the members of that. He thought an appeal might be made to the mining members of the society, so that they might have some papers at their meetings, directly bearing upon mining operations in the county, especially by those members who were proprietors of, or had to do with, mines. He observed, almost with regret that, in other societies in Manchester, it was quite an ordinary thing to see excellent papers upon mining subjects brought forward, though the societies in question did not so directly deal with mining—geological mining especially—as their own did. It seemed almost as if the activity of the colliery proprietors, and coal miners, was directed more in the path of the newer societies than in that of the older society, the Manchester Geological Society, which was a circumstance to be regretted. He referred, especially to a paper to be read that evening by Mr. Alderman Taylor, of Rochdale, on the positive as against the negative system of ventilating mines. There was no



Combes'—P. 31



Byram's—P. 31

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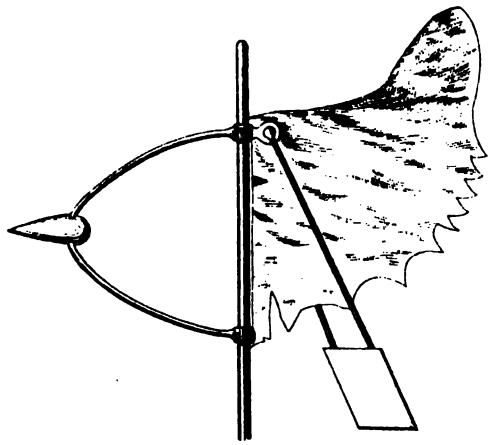

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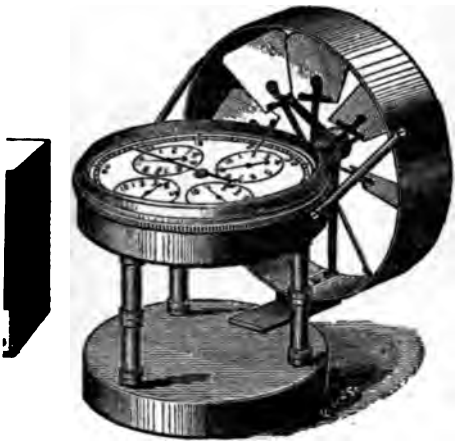
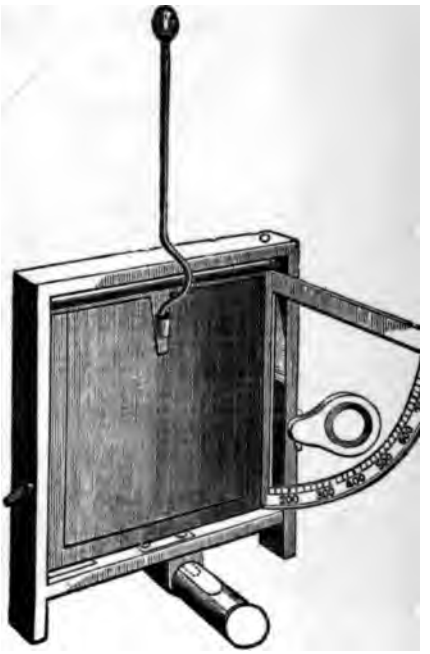
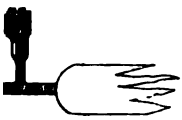
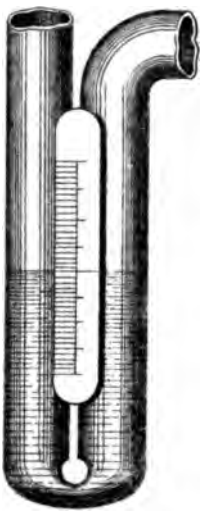
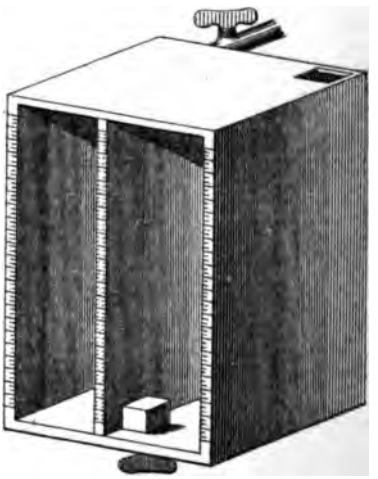




P. 32 Parkes'—P. 32 Dickinson's—P. 32







Lind's Water-gauge—P. 35 Dickinson's Water-gauge—P.

doubt that such a paper would have been as serviceable there as it was likely to be at a meeting of the Society for Promoting Scientific Industry.

The CHAIRMAN said that such a paper as Mr. Plant had referred to, would have been a suitable paper to be read at a meeting of the Geological Society, one of whose objects was mining. He did not, however, think that a lecture to the coal owners was exactly suitable, at the present moment, inasmuch as, at their last meeting, a paper upon a mining subject was read, and he was happy to say there was not a vacant seat in the room.

Mr. AITKEN read a paper "On Drift Deposits on the *Western* Pennine Slopes of the upper drainage of the Rivers Calder and Irwell, with suggestions as to the cause of the partial absence of drifts on the *Eastern* Slopes."

For many years past the attention of geologists has been more or less directed to the fact that a marked difference exists in the distribution of drift on the opposite sides of the Pennine chain, a difference amounting in some instances to an entire absence of that material on the easterly slopes for many miles from the watershed of the country, and over a considerable portion of its length. Notwithstanding that these deposits overspread the great plains of Lancashire and Cheshire in great force, and are found mounting up on the flanks of those hills on their western sides to very considerable elevations, approaching closely in some cases to the culminating ridge, and in others where the chain is crossed by intersecting valleys to some hundreds of feet in excess of the summit level of these gorges. It would further appear, from facts hereafter to be adduced, that although some of these cross valleys attain to only very moderate altitudes, that no communication existed during the glacial period of such a character as to permit of the passage of a body of land ice from one side of the chain to the other.

Whilst, however, these phenomena have not escaped the notice of those observers who have more particularly of late years directed their attention to the surface deposits of the northern counties of England, reference having been made to the subject by Messrs. Tiddeman, Goodchild, Binney, Green, Foster, Dakyns, Ward, and others, yet no serious attempt has, I believe, so far been made to grapple fully with the question.

The subject has long perplexed me amongst other observers, and it is only after a lengthened consideration that I have ventured to suggest a theory which, whilst offering an explanation of the phenomena, does no violence to any of the well-established principles of physical or geological science. My object then, in the present communication, is to supply this desideratum, and to show that the whole of these phenomena are explicable on the supposition that during the flow of the great ice sheet, from the north, over this region, these intersecting channels were sealed and blocked up so effectually as to completely cut off all communication between the eastern and western sides of the Pennine chain, and that the only agent fully meeting the requirements of this supposition, is that of ice, or snow, so consolidated, and fixed in the sinuous channels as to remain stationary and inert, while the great mass of glacial ice, in two sheets, separated by the more elevated portions of the great anticlinal range traversed its eastern and western sides in its march from north to south.

That vast masses of drift deposits overspread the wide plains of western Lancashire and adjoining counties, extending from the Irish Sea, in one unbroken sheet, to the slopes of the Pennine chain, and thence mounting up to higher levels and penetrating almost every upland valley and mountain gorge to considerable elevations, is too well known and too generally acknowledged, to require any amplification

from me on the present occasion. Having, however, traced these deposits in several situations in the neighbourhood of Bacup, and at other places bordering the valley of the river Irwell at elevations not previously suspected. I propose before dismissing the subject to direct the attention of the Society to such facts as have come under my notice, and which I conceive are calculated to throw light upon the arguments to be adduced during the course of this paper. I have previously drawn attention to the fact of drift occurring on Holcomb Hill (1) and on Horncliffe Moor (2), the former at an elevation of 1162 feet, and the latter at 1060 feet. I have also found it at Higher Stack, Bacup, at 1110 feet; at the source of the Easden Clough, near Dirpley Toll Bar, at about 1100 feet; in Shedding Clough, a tributary of the River Brun, at 1040 feet, and a silurian pebble at 1280 feet; in Cant Clough, another feeder of the same river, at 940 feet, and a felstone and silurian pebble at 1115 feet; on the flanks of Blackstone Edge, on both sides of the entrance to the Walsden valley, at 930 feet; on Bull Hill, near Ramsbottom, pebbles of volcanic ash, silurian grit and quartzite (and a number of fragmentary pieces of flint, all of which exhibited unmistakable evidence of having been worked by the hand of man, and which had doubtless been carried there by his agency), at 1371 feet; on Cribden, near Rawtenstall, a stone of volcanic ash, at 1300 feet; and on Brandwood Moor,* lying between Bacup and Rochdale, a considerable number of silurian grit, quartzite, and syenite boulders and pebbles. It thus appears that drift attains an average level of from 1100 to 1200 feet, on the western side of the watershed of the country in the locality under consideration, and that stray pebbles and boulders

(1) Transactions Manchester Geological Society, vol. vii., page 80, (2) *ibid*, vol. xii., page 42.

* Transactions of the Manchester Geological Society, vol. xiii, p. 133.

occur at elevations of about 200 feet in excess of that limit. These erratic stones, found scattered on the summits and sides of the hills above the line at which beds of till and gravel disappear, I do not regard as belonging to the period of land-ice; but that they, in all probability, owe their origin to the agency of icebergs during the submerged or interglacial period, when, according to most glacialists, the country suffered a depression of at least 1200 or 1300 feet from its present level. That glacial ice did not pass over the summit of Bull Hill may be confidently inferred from the vast array of perfectly angular soft grit stones, of apparently local origin, which encumber its crest, and which must, on the supposition of its submergence beneath a sheet of ice, have been either entirely swept away, or so modified by its grinding and abrading action as to leave no doubt as to its former presence there. In a paper read by Mr. Binney, F.R.S., at the Manchester Literary and Philosophical Society, December 27th, 1870, the presence of foreign boulders in these elevated situations, is attributed to other causes. After describing the scattered blocks of stone which are found, more or less, on the tops and sides of the crescents of hills, from south of Clulow Cross, through Cheshire and Derbyshire, to Rivington Pike, in Lancashire, and further northwards, from heights varying from 1000 feet to 1400 feet above the Irish Sea, he suggests that they "are probably the remains of a bed of till, like No. 2,* the clay and pebbles having been removed by denuding causes in the course of a long period of time." I, however, see difficulties in accepting this conclusion, on the ground that whilst foreign stones of very varying sizes appear to be scattered over most of the hills on the western flanks of the Pennine chain, at heights from 1300 to 1400

* Having reference to the classification of drift deposits adoptod in this paper by the author.

feet, no clay or till has, I believe, been detected at a higher level than 1162 feet, raising the presumption that they were never deposited there, and that, therefore, a reason for the occurrence of foreign stones in those situations must be looked for in some other direction.

On the shoulders of the hills overlooking the southern termination of the Walsden defile, where that valley opens out into the basin of the River Roach, at Summit, near Littleborough, drift has been traced to an elevation of 930 feet above sea level, it however appears, that although the summit level of the pass only attains an altitude of 627 feet, that all trace of it disappears in a line about coincident with the watershed of the valley,* beyond which no deposits of this character are met with in travelling east for a distance of about fifteen miles,† the first indication of its presence as a regular bed of drift occurring in the valley of the Calder, at North Dean, near Halifax, where, in sinking for the foundations of a railway viaduct, the following section was taken by Mr. James Spencer, of Halifax, to whom I am indebted for the particulars :—

* Mr. Binney, F.R.S., in a paper read before the Manchester Geological Society, in 1859, on the Lancashire and Cheshire drift, taken from the *Manchester Courier*, of April 9th, 1859, after referring to various elevations to which drift has been traced at several places in these localities, states that he "has little doubt but that some of the most ancient portions of it (drift) have passed the pennine chain through the valley of Todmorden to Hebden Bridge, by the summit valley above Littleborough. As the highest point of the last-named valley is only 610 feet 4 inches above the level of the sea, other portions may have come by Burnley down to Todmorden through the Portsmouth (Cliviger) valley."

† Since writing the foregoing, Mr. Robert Law has pointed out to me a small patch of fine clayey gravel at Ramsden Clough Foot, Cliviger, about a mile and a half from Summit, in which are included a considerable variety of small foreign pebbles. This gravel, however, presents a different character to the true glacial drift to the west, and will probably turn out to have been re-arranged by pluvial action subsequent to the glacial period. In this view I am supported by the opinion of Mr. Law, the discoverer.

Soil	1 foot.
Fine alluvial sand	8 feet.
Gravel derived from local rocks	2 „
Gravel containing granite, trap, slate, and silurian rocks	3 „
Feet	14

It is, however, stated that an occasional pebble foreign to the district has been noticed in the bed of the River Calder, a little further to the west than the spot just named.*

Close to the railway bridge at Elland, in the bank on the south side of the River Calder, under about 5 feet of sandy loam, a bed of gravel exists, about 4 feet of which is exposed, and which, I am informed by Mr. Davis, F.G.S., of Greetland, has been proved by a well sinking to be from 15 to 20 feet in thickness, in which red granite, silurian, porphyritic greenstone and other foreign pebbles occur, and at and below this point examples of these rocks may be detected in the bed of the river wherever gravel is exposed. This is situated at an elevation of about 200 feet above sea level.

At the Elland Railway Station the following section has been exposed by some recent operations of the Company:—

	Ft.	In.
Soil	1	4
Fine subangular gravelly surface wash	2	6
Loamy sand ..... 6 inches to	1	0
Fine sandy gravel	2	6
Gravel coarser than that above, stones all water-worn and much abraded, of local origin, resting upon a bed of carboniferous shale	5	0
Total	12	4

* Dr. Alexander, in describing the geology of the parish of Halifax, in the Transactions of the Geological and Polytechnic Society of the West Riding of Yorkshire, 3rd June, 1841, p. 201, mentions "that in prosecuting the works on the line of railway, some blocks of granite had been found near Hebden Bridge."

And at the cemetery, a few hundred yards to the N.W. of the last-named place, and at an elevation of about 380 feet, a bed of gravel, sand, and loam reposes upon the carboniferous shale, varying in thickness from 5 feet to 10 feet, analagous in character to that exposed in the section last described. And in the Shibden valley deposits similar to these are found at about a coresponding elevation.

In the three last named instances the stones composing the gravel consist of well rounded water-worn rocks, derived exclusively from the basin of the Calder and its tributaries, not a foreign pebble being found incorporated with them. These gravels may therefore be regarded as having a purely local origin, and date from the time when the river Calder ran at this level, and are consequently in no way connected with the glacial drift which occurs in the valley below.

Turning now to the Cliviger valley, we shall find that a similar condition of things exists there also to that already described as occurring in the Walsden vale, viz., large deposits of drift on the north-westerly side of the watershed and an absence of it on the south easterly slope, its southerly termination taking place at Holmes Chapel, about one mile from the summit level at Calder Head, the height of which is 768 feet. Notwithstanding this, we find, by tracing out the position of these deposits in the side valleys, to the N.W. and E., that they rise up to elevations greatly in excess of the watershed in the valley below. In Easden Clough, a lateral stream falling into the Calder valley, west of Holmes Chapel, I have traced drift to the height of about 1100 feet; and to the east, in the tributaries of the river Brun, a stream which falls into the Calder at Burnley, I have found drift at an elevation of about 1040 feet, and two or three stray foreign pebbles at upwards of 1200 feet.

The drift in these last-named upland valleys, up to the

height indicated, being so fully charged with carboniferous limestone pebbles that vast quantities of the matrix have been systematically washed away, leaving the harder and more bulky materials behind, from amongst which the limestones were collected and burnt into lime. The extent to which this was formerly prosecuted, is attested by the scarped denuded sides of the valleys, the vast heaps of rejected valueless stones which greet the eye over a wide area, and the crumbling half-ruined kilns which stud the valley in all directions.

If we next direct our attention to the north, we shall there meet with precisely similar conditions. We have it upon the testimony of Mr. Tiddeman* that in the great watershed of the north, opening between the basins of the Ribble and the Aire, whose summit level has an elevation of 700 feet above the sea, the drift which rises up to its highest part terminates (as I gather) near that spot. After describing the general features of this watershed, the author goes on to state—"I am aware of the difficulties that are raised about the east side of the Pennine Chain being so free from drift; but all geologists agree that some, at all events, does exist, and the patches that are left cannot be considered to have been dropped just as they are in isolation. The difficulty lies rather in the question—how has the mass of it been removed? That is a question which I cannot undertake in this paper; I do not know the ground sufficiently to hazard an opinion; nor, indeed, does the matter come within the scope of this enquiry." I am informed that drift again presents itself in this valley further to the east; and that deposits of this

* In his paper "On the evidence of the ice sheet in North Lancashire, and adjacent parts of Yorkshire and Westmorland."—Quarterly Journal of the Geological Society, for November, 1872, p. 478. A contribution the value of which it is difficult to over-estimate.

character are found in the neighbourhood of Bradford in moderate plenty, leaving a barren district of many miles in length between the two drift covered areas. Again, at page 486 of the same paper, we have further testimony in the same direction, in the following passage:—"In that part of the district, east of Pendle, Mr. W. Gunn's observations confirm my own, to the effect that there are no boulders of other than local rocks." One exception alone being mentioned, a satisfactory explanation of which is given by Mr. Tiddeman. From the above extracts it will be perceived that whilst Mr. Tiddeman fully recognises the difficulties connected with the consideration of this subject, he declines to hazard an opinion as to the physical causes which have led to so marked a difference in the distribution of drift deposits on the two areas. By reference to the admirable map which accompanies the paper already quoted from so copiously, it will be found moreover that no ice scratches are marked as occurring to the east of the watershed of the country, and further, that all those recorded near to that line run in a direction closely approaching to north and south, with one exception, which occurs on the low ground separating the valleys of the Ribble and the Aire already alluded to—and this solitary instance may, I think with strong ground of probability, be ascribed to local influences exerted towards the close of the glacial period, when the great ice sheet had been supplanted by local systems of glaciers.

If we next turn to the south, we are still confronted by precisely similar phenomena. My own observations, made in the neighbourhood of Castleton, in Derbyshire, which is situated just beyond the central axis on the eastern slope of the Pennine range, being fully confirmed by Professor W. Boyd Dawkins, F.R.S., who, in speaking recently, at the Manchester Geological Society,

upon the superficial deposits in that locality, observed*—"From what I can see, there is nothing whatever in this deposit to separate it from the superficial deposits in the valley near Castleton, which you will find pretty well everywhere. When I examined these the other day, in the company of Mr. Prestwich and Mr. Tiddeman, we came to the conclusion that they are not glacial, but the result of sub-aerial wear and tear of the rocks in the neighbourhood." We thus find that over this large area, extending from Skipton in the north, by Todmorden to Castleton in the south, that a general absence of drift deposits and all other indications of glacial action characterises the eastern slope of the great axial chain, for a considerable distance from its summit.

We may now enquire if there is any legitimate reason for supposing that drift was at one time deposited over the now barren area, and that its absence at the present time is to be accounted for by subsequent denudation, as suggested by Mr. Tiddeman in the paper previously referred to. It appears to me—from a full consideration of all the facts—exceedingly problematical that this can have been the case, for it is difficult, if not impossible, to conceive of any known force which could act in so capricious and anomalous a manner as to have swept and cleared off the surface of the driftless area to the east so completely that not a trace of its former existence should remain, even in the deep sheltered valleys which intersect the district in all directions, and thus presenting conditions of the most favourable character for its preservation, and yet at the same time leave intact the vast bodies of drift which so completely envelope the country to the west. It is well known that large bodies of drift overspread the eastern plains of Yorkshire, some of which found its way up the western prolongations of the

* Transactions of the Manchester Geological Society, vol. xiii., p. 124.

valleys, formed by the streams issuing from this upland district; but which appear invariably to terminate at moderate elevations, either on the spurs of the hills or in the valleys, and in situations where it might reasonably be expected that deposits of this kind, derived from the eastern system of glaciers, might be found.

If, however, it should eventually turn out upon subsequent examination that scattered erratic boulders, or even small patches of foreign *débris*, should be discovered, either in the upland valleys or on the hilly slopes, no difficulty will arise in reconciling this fact with the hypothesis herein advocated. For it is not only possible but highly probable that during the period of submergence of the land, when these valleys,—assuming a depression as already suggested of some 1200 or 1300 feet,—would be narrow straits, through which an occasional iceberg might be drifted, either by an ocean current or a prevailing wind from the north, east, or west, dropping, as it floated along, a stray pebble or block of stone. The boulders already referred to, as occurring at Hebden Bridge and in Cliviger, may belong to this class. The presence, therefore, of small bodies of foreign matter in those situations—should they occur—might confidently be attributed to that cause, and would not consequently in any way invalidate the hypothesis advocated in this paper.

Having thus far endeavoured to prove, and I hope successfully, that a marked difference exists in the distribution of drift on the opposite sides of the Pennine chain, it now remains to show that this phenomenon has in all probability been brought about by the valleys in question having been filled up during the glacial period by accumulations of ice or snow held firmly in their places by the physical and other characters of the gorges themselves, acting in combination with the force exerted by glaciers

pressing against the ends of these blocked-up channels, and thus effectually holding stationary the embedded masses in the places of their deposition.

To a full and clear comprehension of this subject it will be necessary to glance at the physical and geographical features of the district, and to trace their relation and bearing to the surrounding country. In treating of this branch of the subject, our attention will be principally directed to the area lying between Burnley and Littleborough on one side and Todmorden on the other, a district embracing the two deep valleys of Cliviger and Walsden, in which are contained two of the lowest watersheds in this part of the range. The Pennine chain, as is well known, is an elevated range of hills, commencing near Derby, in the south, traversing the central part of the country in a general direction of north and south, and terminating at Cross Fell in the north, and having a general elevation in its higher summits of from 1800 to 2000 feet, but rising, in a few instances, to a height considerably in excess of even that. The breadth of the chain averages about thirty to forty miles, from west to east. In that part of the range which gives rise to, and is traversed by, the Rivers Calder and Irwell, the general elevation of the hills ranges from 1300 to 1400 feet.* They consist mostly of rocks of millstone grit-age, overlaid on the easterly and westerly flanks by lower coal measure strata. Into these rocks the River Calder, which takes it rise on the elevated ridge of moorland, lying between Bacup and Todmorden, has excavated for itself a deep, winding, narrow channel, which penetrates the strata at Todmorden at a distance of about four miles from its source to a depth of upwards of 1000 feet from the summit elevations of the hills in the

* Cross Fell, 2930 feet; Kinder Scout, Derbyshire, 2150; Pendle Hill, Lancashire, 1830 feet; Boulsworth, 1689.

immediate neighbourhood.† In consequence of which a series of Yoredale beds, from 400 to 600 feet in depth, are brought to light in the valley, where in its course it cuts across the line of the great anti-clinal axis of the chain. Such then are the general features of the country. As, however, the structure and character of this district has an important bearing upon this subject, it will be necessary to examine them a little further in detail.

If, then, we take Todmorden as the central point of the district, from which to commence our observations, we shall find that it is situated almost on a line with the highest summits of the Pennine hills, in a deep gorge at the junction of the streams which flow through the two defiles already mentioned, and on the main axis of that great Pennine fault, which traverses the range in a direction of NN.W. and SS.E., and in a line roughly coincident with the Walsden and Cliviger valleys, the effect of which has been, not only to fracture and break up the rocks to a marvelous extent, but also to cause a reversal in the dip of the strata—those on the east dipping at an angle of about 5° to the S.E., and those to the west declining at an angle of from 20° to 45° to the W.S.W.

This fracturing and breaking up of the crust, as would naturally be expected, has resulted in the production of a line of weakness, thus bringing about a condition of things most favourable to the exercise of sub-aerial forces to their fullest extent; to whose operation, exerted over a vast lapse of time, must be attributed the formation of these narrow deep defiles. The period at which these disturbances took place is fixed by Professor E. Hull, F.R.S.* about the latter part of the Permian period, so that abundant time is afforded,

* Todmorden, 209 feet; Thieveley Pike, 1474 feet; Dirpley Hill, 1429 feet; Hogshead Low, 1460 feet.

† Quarterly Journal of Science, 1868, p. 331.

by the means suggested, for their degradation to their present low levels.

Starting from this centre, we shall find that three valleys radiate in lines almost equidistant from each other, one stretching off through Walsden to Littleborough, for a distance of about five miles, in a direction a little west of south; another taking a north-westerly course, through the sinuous gorge of Cliviger to Burnley, a distance of about eight miles; whilst the third, the valley of the Calder, takes an E.N.E. direction; thus presenting three deep narrow tortuous channels, hemmed in on every side by massive walls of rock, cut into at intervals along their course by the entrance of tributary streams, reminding one forcibly, when traced on a geological map, of the device known as the "three legs of man" which characterises the Manx copper coinage.

The watersheds of Walsden and Cliviger valleys are at a comparatively low level—that in the first having, as already stated, an altitude of 627 feet above sea level, being eaten into to a depth of 330 feet below the shoulder, or first platform bounding the valley;* whilst that in the second is crossed at an elevation of 768 feet, and is excavated to a depth below the immediate country of 475 feet, a depth which would be greatly increased if the summit level of the surrounding hills was taken as the datum line for measurement. The valley of the Calder, which forms the line of drainage through which the waters of the aforesaid tributary valleys, from their junction at Todmorden, pass off to the German Ocean, being cut into to a depth considerably in excess of those already described.

If, then, we view these valleys in relation to the initial period of their formation, structure, and physical characters, the total absence of drift or other indication of ice action

* Professor Hull, Geological Magazine, vol. iii., p. 475.

within their boundaries, or the marked contrast presented in the configuration of these and other valleys in the neighbourhood, and the general surface contour of the surrounding district, and compare them with the country on the western slope of the chain immediately beyond the watershed, where ice is known to have been, and where, through its abrading action, the hills and dales lose their stern, angular character, and assume a soft, rounded, and flowing appearance, indicating unmistakably the operation of divergent forces and the existence of wholly different conditions. We shall have no difficulty in concluding that glacial or land ice has had no share in their formation or subsequent modification, but that they owe their origin to the fracturing of the rocks in the first instance, and subsequently to the operation of sub-serial forces.

Having now at some length pointed out the structure and general features of the district, I shall proceed to offer a few reasons for the assumption that during the glacial period these lines of communication were blocked up by snow or ice so as to cut off all connection between the two sides of this chain of hills.

On the approach of the long winter which preceeded and heralded in the period when ice overspread the county of Lancaster and the whole of the northern part of our island, the severity of the climate would gradually increase, during which time large accumulations of snow would take place, and ice be formed in deep and sheltered situations like those presented by the Walsden, Cliviger, and Todmorden valleys. The snow thus accumulated to a depth of 800 to 1000 feet would, by being partially melted and re-congealed, become in time a consolidated, compact mass, of a density and consistency little, if at all inferior, to that of ice itself. Accepting, then, this proposition, we shall have no difficulty in concluding that these bodies, held firmly in their places,

in the tortuous serrated valleys, which are so constructed, and hold such relations to each other that any attempt to move on the part of the accumulations in one of the arms would be resisted and counterbalanced by the opposing force of the other two branches, each of which would have a tendency to move in an opposite direction, and would thus be able to offer an effectual resistance to the force of the great northern glacier on its approach to dislodge them from their strongly entrenched positions. The resistance to all motion on their part being still further increased by the pressure of the great glaciers acting upon the terminal portions of the Calder and Walsden arms at the mouths of the valleys by which those bodies, if in motion, would have to emerge with a force equal to that exerted at the northerly end where the glacier would seek to effect an entrance therein, thus completely neutralising each other, and preventing any motion on their part taking place. The progress of the glacier, in its journey south, being thus arrested by an impassible barrier, at or near Holmes Chapel, in the Cliviger gorge, where the valley suddenly contracts and becomes hemmed in on both hands by massive beds of grit rocks, in some places almost vertical, it is evident that the ice, forcing its way so far, would be compelled either to move on over the embedded and stationary mass, or be deflected from its course, and compelled to take a more westerly direction, that part of it was forced over the intervening space, separating Easden Clough from the Whitewell Valley at an elevation of 1170 feet, and passed on, east of Dirpley Hill and the high land adjoining, into the valley of the Irwell, thence skirted the hilly district east of Bacup and crossed Brandwood Moor—the dividing line between the basin of the Roach and Irwell—continued its course on to Manchester and the great Cheshire plain, can be shown upon evidence of the most conclusive character, whilst another stream of ice

doubtless crossed from Burnley into the Whitewell Valley by the Wholaw Nook Pass, becoming there confluent with the arm already described, the main body moving off in the direction of Burnley and Accrington, on the westerly side of Hambledon Hill, from thence pursuing its course south and uniting with the other streams finally debouching on to the plains of South Lancashire.

In support of the theory that a large body of moving ice meeting with resistance sufficiently powerful can be either entirely arrested or its various portions be endowed with varying and diverse motions, we have the authority of His Grace the Duke of Argyll, late President of the Geological Society of London, who in his Presidential address to that Society, when speaking upon the subject of the formation of rock basins by the action of ice, asks* "What would be the behaviour of that portion of a glacier imbedded in a rocky hole; would it move as freely as a glacier lying on a level or on a descending slope? Is it quite certain that it would move at all? Would not the friction and resistance be so enormously increased as to bring the lower portion of the glacier to rest, and allow the upper part of it to slip over the lower part, as we know it actually does, even where the lower ice is not thus embedded?" And again, "It is quite certain, I apprehend, that a rocky depression of some certain depth and thickness would hold absolutely fast any mass of ice which had been forced into it, and that any superincumbent mass of ice in motion over it would have to part company altogether with this embedded portion, even as the upper part of the *mer de glace* does now part company from its own base by a double rate of motion." Professor Ramsay has also pointed out the fact that the motion of the lower portions of glaciers are powerfully influenced by the physical form and character of the

* Quarterly Journal of the Geological Society of London, vol. xxi.

channels in which they move. And very recently Mr. Goodchild, in writing upon drift,* observes: "What I particularly wished to call attention to here, is the fact that the direction of transportal of boulders is very often at right angles, and in a few cases is directly opposite to the course taken by the sole of the ice sheet.

It thus appears that there is the most satisfactory evidence to prove that one portion of a mass of ice may be stationary, whilst another may continue its onward progress; or that one portion of a body of ice may move in one direction, and another portion be pursuing a course considerably at variance with it; and that, consequently, it is reasonable to infer that a glacier might have moved bodily over the area occupied by the Todmorden valleys, and yet not disturb the jammed masses below. I am, however, inclined to the opinion, as previously stated, that ice never overflowed the higher elevations of the Pennine hills in this locality, for had a glacier at any time overspread them, no doubt can exist that it would have left unmistakable evidence of its presence in moulding the surface contour of the country, and that morainic and other matter must of necessity have been left behind on its retrocession, as a memorial of its former presence; and this, too, if only the upper portion of the glacier had been endowed with motion, leaving the basal parts locked fast in the deep channels below.

I am aware that the acceptance of the hypothesis that the great ice sheet did not in this district attain a thickness sufficient to raise its surface to a level with the crests of the hills, appears to clash with the observations of geologists made further to the north. Mr. J. Clifton Ward, in his important paper† "On the glaciation of the northern parts of the lake district," gives instances of ice scratches

* Geological Magazine, vol. 1, Decade 2, page 504.

† Quarterly Journal of the Geological Society of London, vol. xxix., p. 425.

occurring in that district at elevations of over 2000 feet, and in one case, in the Helvellyn range, even as high as 2500 feet; and Mr. Tiddeman—in the paper already so frequently quoted from—describes ice scratches on Ingleborough at a height of 1350 feet, and on Bowland Knotts at 1400 feet.* And, at page 479, he makes use of the following words, "I can conceive its being quite possible that the ice sheet went quite over Pendle."†

No difficulty, however, I conceive, will arise by supposing the ice in the latitude of Bacup to have had a less thickness, by some hundreds of feet, than that to which it attained in the lake district further to the north, if we take into consideration the gradual slope of the ground, the waste by melting to which it would be subjected in travelling south, and its tendency to spread out and become diffused on reaching the flatter and more level plains of Lancashire and Cheshire. On these and other grounds I fail to see that any difficulty will arise by assuming that the ice sheet was confined to a thickness of some 1200 or 1300 feet in this part of Lancashire, although issuing from the elevated mountainous region of the lake district with a thickness of 1500 or even 1800 feet.

Since penning the foregoing, a copy of the Geological Memoir, by Messrs. A. H. Green, C. le Neve Foster, and J. R. Dakyns, on the Geology of the Carboniferous Limestone, Yoredale Rocks, and Millstone Grit of North Derbyshire and the adjoining parts of Yorkshire, has come into my hands, which I find upon perusal so far supports the conclusions at which I had previously arrived, touching the unequal distribution of drift on the axial chain of the country, that I may be pardoned trespassing a few moments longer upon the patience of my audience, whilst bringing

* *Ibid*, p. 476.

† Pendle hill has an elevation of 1831 feet.

this paper to a conclusion, by reading an extract from it, in confirmation of the views herein enunciated, commencing at page 128, and proceeding as follows:—

"The distribution of the drift over this country is, in general terms, as follows:—On the west the plain is everywhere thickly covered with it; it runs up the slopes of the central table land, and patches of it and erratics are found on the table land itself—along its western margin—up to a height of 1200 feet above the sea. The distribution on the south is very nearly the same as along the west side, but the plain is not so completely covered, and the greatest height reached is rather less. With the exception of the patches on its western margin just mentioned, the central plain is perfectly free from drift; but in the one case of a valley which cuts well across it—that of the River Wye—there is reason to think that the drift has found its way through the gap; at all events, drift is found along the valley. Passing to the eastern side of the range, we find a vastly different state of affairs; for a distance of from ten to twenty miles from the eastern side of the central table land, the plain is, with the exception of a few erratics and little patches of boulder clay, altogether free from drift; and when beyond this we do reach a country where drift comes on, we find it there, and, instead of wrapping the whole land in one widespread covering, occurring only in scattered patches. It seems, too, that the drift on this side contains fewer foreigners, and is more largely made up of local rocks than to the west."

On the motion of Mr. PLANT, seconded by Mr. MARTIN, a vote of thanks was passed to Mr. Aitken for his paper.

Mr. MARTIN suggested that discussion upon Mr. Aitken's paper should be postponed until the members had had an opportunity of reading it in the Transactions.

Mr. PLANT supported the suggestion, and added that the subject of the paper was in some respects so novel, that he should hesitate without due consideration to venture an opinion either of approval or disapproval of the views advanced. It was valuable, at any rate, because it was a record of the personal observations of Mr. Aitken over a large area which had not been touched upon to the same extent by other geologists.

The CHAIRMAN: It is quite clear that Mr. Aitken must have devoted a great deal of study and observation to have prepared such a paper, dealing, as it does, so much with detail, and apparently challenging some views that have been arrived at, in some respects, by geologists, and confirming them in others. The whole of the glacial theory, to my mind, is based upon pure supposition. Although geologists have agreed, for the present, to accept it, and it has been placed in the geological code, it is not many years ago that this theory was not admitted into their code. This drift deposit may, to my mind, be accounted for by entirely different and much more plausible and satisfactory causes than by the transit of it.

The discussion on the paper was postponed.

Mr. PLANT read the following paper:—

A SUBMERGED FOREST NEAR HOLMFIRTH.

The existence of considerable tracts of submerged peat and forest along the sea coasts, and within the area of the wide estuaries of some of the rivers of Great Britain, is a feature well known to be of not unfrequent occurrence, and the most experienced geologists have arrived at the conclusion that, in the majority of such cases, the land has

and pointed out many features of interest connected with the locality. The trees were found during the formation of the Upperthrong reservoir, which lies in a shallow depression, between two long ridges of lower coal shales; the depression is a rushy marsh in the upper part, where it catches the drainage from the eastern flanks of Harden Moss, and at the lower end a small brook runs out to join the Holme, at Bridge Mill, below Holmfirth. The site of the reservoir is known by the name of the Hillicks, and, altogether, the depression may contain about 40 acres of surface.

The reservoir is dug out of a deposit of no great depth, which principally consists of clay and black boggy peat, both lying on coal measure shales. the depth of the peat and clay varies; an average depth would not exceed six feet. One measured section gave the following:—

	Ft.	In.
Surface boggy turf	1	0
Clay and marl	2	6
Black peat in which the stumps of trees occur	4	6
Total	8	0

The excavation, when I saw it, was about 200 yards long by 70 yards broad, and had not been carried below the black peat and clay; yet in some places the hard shales were seen forming the floor upon which the trees had once grown. This area contained the prostrate trunks and upright boles of about 30 large trees which had had the black peat removed from about them, and were otherwise undisturbed. The trees were lying with their heads pointing down the valley in a direction N.W. to S.E., and most of them had been snapt off, so as to leave about 3 feet of the bole standing; yet, in one instance, the whole tree had evidently been uprooted; the roots were firmly held in the clay and fissures in the shales. Some of these trunks were 40 feet long and of good girth at the upper part, showing

the age of such trees to be not less than half a century. The wood was black and soft, but perfectly sound at the heart; the small branches and leaves had to be searched for in the heaps of black peat heaped up on the banks of the excavation, and it was full of such matters.

The trunks, which were clearly identified, were those of oaks, beeches and birches, the latter predominating; but as many of the trees and roots are set up as ornaments in the flower gardens about Holmfrith, it is yet possible to decide as to other species than the three identified, and a larger number of trees have been exhumed since my visit.

There can be no hesitation in classing these buried trees with those of which I have spoken as found in the peat beds on the Lancashire moors, although the deposit is not exactly identical in some respects.

The course of events appear to lead to a conclusion somewhat like this:—

At one time, in past ages, on the hills about Harden Moss, clumps of large oaks, beeches, and birches grew in vigorous health. Suddenly, by some catastrophe, the trees were broken off near their roots, and fell prostrate where they now are found. The drainage from Harden Moss soon after is stopped, and converts the place into a swampy bog. Peat is then formed, and envelope the trees, and the whole becomes dry and hard. After a time a small lake is formed over the peat, the waters from higher ground bear fine clay and marl, and spread it over the peat to a depth of about 3 feet, then the lake drains off, and the marshy turf grows on the clay, and an aspect is given to the shallow depression which appears to have existed from the earliest historical time to the present day.

Mr. Aitken: I am very glad that Mr. Plant has brought this matter before us, for it is a question that has engaged my attention, and I dare say that of other geologists. In the neighbourhood of Bacup I have noticed similar features

to those described on the tops of our hills. During an excavation, made some years ago when constructing a road across Broadwood Moor, at an elevation of 1100 or 1200 feet, peat was cut into to a depth of about seven feet, and at the base of that deposit was revealed a large number of trunks of trees of varying sizes, from 1 foot to 1½ feet in diameter. Along with these were found, as described by Mr. Plant, large quantities of hazel nuts, boughs, &c. I visited the place, and saw one trunk of a tree about 18 inches in diameter, which was snapped off at about two feet from the base; the roots were still in position. At the present time no trees will grow at this elevation, even of the smallest dimensions. I also remember, that on the summit land, between Bacup and Todmorden, at a little higher elevation than that I have mentioned, a large prostrate trunk was laid bare some years ago in excavating for peat, which Mr. Stansfield, of Todmorden, took observations upon and described. The strange part of the matter is that trees should grow in such positions in former times, but will not do so now; and I should have been glad if Mr. Plant had offered some solution of that difficulty. I am not prepared to offer any suggestion, but the subject is well worthy of attention, and I should be glad if some thoroughly competent person would investigate it, and try to adduce some practical reason for the change that has taken place.

On Broadwood Moor, along with the trunks of trees, found at the base of the peat, were a very remarkable number of beautifully fine, hard, and crystallised pieces of gannister, which had been derived from the denudation of the gannister bed of coal, which formerly overspread Broadwood Moor. This has now disappeared, with the exception of one little patch on the very highest summit. These blocks of gannister, some of which were large, were intermingled on the same surface which the trunks of the trees occupied at the base of the peat. I do not know that they

have any connection with each other. The denudation which took place, resulting in the removal of the higher portion of the coal measures, must have been at an immensely earlier period than the formation of the peat, and the covering of the trees which subsequently took place. The subject is one of considerable interest, and I am sure we are obliged to Mr. Plant for calling attention to it.

The CHAIRMAN: I think the paper is the more valuable, inasmuch as Mr. Plant has confined himself to facts without going into any theoretical supposition to account for the cause. Most of us have had opportunities of seeing large trunks of trees in peat mosses, and must have been surprised at the way in which they had come there, seeing that such trees will not now grow in the locality. A few things one might suppose, with reference to the circumstances under which they have existed: either the wood must have become changed in character so as not to be so hardy now as it was in olden times, or the temperature must have changed, or the subsoil must have been acted upon in some way. I was rather struck with one part of the paper where allusion was made to a small lake which Mr. Plant supposed had been formed on the peat moss, and that it became filled with water. With regard to most peat mosses, the conclusion I have arrived at is that there has been a lake to begin with, and that the lake has become gradually filled up and formed into land by the growth of the peat—not by the filling up of water on the top of the peat. However, it is a very interesting subject, and perhaps all the better inasmuch as it is left merely as a record of facts, without going into theories.

Mr. AITKEN asked what the elevation of the submerged forest described by Mr. Plant would be.

Mr. PLANT: Between 1000 and 1100 feet.* The lake

* The highest point on the West, two and a half miles from this spot, is West Nab, 1644 feet; and on the South, three miles off, lies Black Moss, 1529 feet, and Harden Moss, about 1400 feet.

spoken of was, perhaps, not quite understood. The conditions are these: there is a floor of hard rock, pretty much of the nature of the gannister of which Mr. Aitken has spoken, and the rootlets of the trees are found to have grown down into the crevices between the fractures of this rock. There could not have been a lake at the time when the trees were commencing their growth, because they would not grow under water, and the peat surrounds the trees, completely embedding them to a depth of from 5 ft. to 7 ft. in the deepest parts—the average depth being about 4 ft. 6 in. Then upon that comes this close capping of tenacious clay, which is exceedingly fine—quite like pot clay—that is 2 ft. 6 in. in thickness. It is at the time when this clay was deposited that I suggest there may have been a lake, and all the trees had been buried below in the peat bog. Many of the buried birch trees I measured had a girth considerably larger than my body, which shows that they must have flourished—not have been merely miserable dwarf things, but flourished, and made a fine forest where they grew. I have no theory to advance with regard to them, and nothing I have read yet explains the circumstances under which these submerged forests once existed.

Mr. Plant exhibited a metatarsal bone of a deer, taken from the peat beds at Barton-on-Irwell. It was highly impregnated with blue phosphate of iron, and was a good example of this mineral. The localities for phosphate of iron, *Vivianite*, were not numerous in England, but it is usually found on the extraneous bones of animals buried in turf and peat, whose decomposition, it is conjectured, afforded phosphoric acid to the iron ore, so abundant in other forms, in beds of peat. The ordinary formula for this mineral was:—

Oxide of iron	47·50
Phosphoric acid	32·00
Water	20·00

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART III. VOL. XIV. SESSION 1875-6.

At the ORDINARY MEETING of the Society, held on Tuesday, 29th February, 1876.

Professor W. BOYD DAWKINS, F.R.S., in the Chair.

Mr. GEORGE PEACE, Beech House, Eccles, was elected an ordinary member of this Society.

THE SUB-WEALDEN EXPLORATION.

The CHAIRMAN said: Perhaps it may interest the Society to know the progress which the Wealden boring has been making during the last three or four weeks. I may say that last Friday the committee met in London, to consider the question as to whether we should continue the boring or not. The general opinion of the committee was that we should carry it down to 2,500 feet. At the present time we have got down to 1,905 feet, and are only in the Oxford clay. Certainly it seemed to the committee a very desirable thing that the boring, which had gone to such a depth, should go 500 feet lower—that is to say, to the depth at which the Palæzoic rocks have been hit in Westphalia and other places on the continent. Of course, if we are able to carry this out, it will only be by a very considerable expenditure of money, and I think that very possibly we shall be

able to do it. That, of course, will depend upon the amount of support which we get from the public.

Mr. GREENWELL asked whether the thickness was known, of the Oxford clay, at the nearest point to the boring? The evidence which might exist of thickening or thinning out of the strata would, he thought, form some guide as to the probabilities of their getting through the Oxford clay within a reasonable limit of time. Of course, when the boring had got below the Oxford clay they would still possibly be a long way from any coal measures or anything of that kind. At present, nothing was known except that, when they crossed into France, they found that the strata between the greensand and the coal measures were all wanting, or thereabouts. There was the possibility of there being the same absence of those intermediate formations in the Wealden district.

In the course of further conversation, Mr. GREENWELL mentioned that at South Wingate, 12 miles or more south-east from Durham, a bore-hole had been sunk which, after passing through the magnesian limestone, had penetrated the mountain limestone.

The CHAIRMAN: That would exactly corroborate the view which Professor Ramsay gave to the Coal Commission, namely, that the magnesian limestone, in the South Durham coal field, rested on the mountain limestone and the millstone grit; whilst further south—in the direction of Leicestershire—it passed on to the coal measures again.

Mr. GREENWELL said that the bore-hole to which he referred had been sunk on the south side of the denuded millstone grit, and had gone through the magnesian limestone direct into the mountain limestone.

The CHAIRMAN said it certainly seemed to him that, supposing they were obliged to give up the Wealden boring, another ought to be tried, further to the north. He thought

it was very possible indeed that the line of flexure between Somersetshire and Belgium passed a little way to the north. Because the coal troughs, both of Belgium and of Somersetshire, have a tendency in that direction. The Belgium troughs run with their long axes pointing in the direction of the Lower Thames Valley, and, to some extent, the Somersetshire, South Wales, and Pembrokeshire fields too.

Mr. GREENWELL: Your object in placing this bore-hole in the Weald was to avoid having to bore through the chalk. That may have to be faced in the Valley of the Thames.

The CHAIRMAN: Yes; our object was very simple. We choose the very lowest point in the secondary strata that we could find in the south-east of England—that is very nearly the centre of the anticlinal of the Weald—and the thickness of the clay underneath is quite without precedent. Nine hundred feet of Kimmeridge clay is a thickness which we have not known yet.

Mr. DICKINSON said that when the boring was completed it would be an interesting thing for the Society to have copies of the sections and other records.

The CHAIRMAN: I shall have great pleasure in presenting to the Society, when the work is finished, every document relating to it, from the beginning to the end. I have the entire series. It may hereafter be historically interesting. I have no doubt that this is the first of a series of borings which will ultimately be carried out, and which will prove the existence of coal.

EXPLOSIONS IN MINES.

Mr. GREENWELL said: I think it would be well if this Society would consider the possibility—I won't go further than that—of collecting information, through those members who are specially acquainted with collieries, as to a connec-

tion that may exist between explosions and standing fires, or goaf fires, in mines. Much has been said lately about these disasters being caused by the use of gunpowder; and, without entering on that question at all, as a question in itself, I would like to make one remark, which is this—about 80 per cent. of all explosions take place between the months of November and February. Now, of course, we know perfectly well that, in the working of coal, gunpowder is used all the year round. We also know that ventilation in collieries is, as a rule, somewhat more slack in summer time than it is in winter; and there is generally, I think, greater probability, so far as ventilation and the issue of gas is concerned—that is to say, from these things alone—of explosions occurring in summer than in winter. But we find that the reverse is the fact. Now in winter, when we have ventilation a little more active than it is in summer, and when we have the air in finer condition, and better fitted, probably, for making an explosive mixture with gas, we find that most accidents take place. At the same time, is it not possible—I merely throw this out as a hint—that where there may happen to be a standing fire in a gob, which in summer time is kept in a dead, smouldering condition, from the less activity in the ventilation—is there not a possibility of that being fanned, in the winter, into something that will ignite gas? Now, if we can put those two things together; if we can fancy, in our minds, that gas in a goaf may possibly have a little more air in winter added to it than it would have in summer; and if we find that that additional quantity of air might fan the fire into a blaze during winter, when it would not in summer, is it not possible that we might, by gathering some statistical information, arrive at a conclusion as to whether there might not be some connection in that way between explosions taking place in winter and not in summer? We want a little more

information as to the number and condition of standing fires in mines. I knew myself a case, not very long ago, in which there undoubtedly were explosions of gas which took place from fire that was standing in a goaf. If the quantity of the gas had been large, instead of small; if that goaf had been larger than it was, there was nothing, physically, to have prevented a very heavy explosion taking place, instead of a series of slight ones. What occurs in one mine may occur in others. It may possibly have taken place at the Oaks, for instance.

Mr. DICKINSON said that the Oaks explosion of 1866 was clearly traced to the firing of a shot, in which an excessive charge of gunpowder was employed to blow the coal out in the "stone drift." The mine was a magazine of gas, its ignition being only a question of time. In 19 out of 20 cases the cause of explosions was distinctly traced.

This concluded the business of the meeting.

At the ORDINARY MEETING of the Members, held 24th March, 1876.

Mr. JOSEPH DICKINSON, V.P., in the Chair.

Mr. PETER G. CUNLIFFE, The Elms, Handforth, was elected an ordinary member of the Society.

No other business was transacted at this meeting.

At the ORDINARY MEETING of the Members, held 25th April, 1876.

Professor W. BOYD DAWKINS, F.R.S., in the Chair.

Mr. HERBERT A. WOODWARD, Kearsley Collieries, Swinton, was duly elected an ordinary member of this Society.

DISCOVERIES AT CRESWELL CRAGS.

Before the commencement of the ordinary business, Mr. PLANT, one of the honorary secretaries, said he should like to call the attention of the members to a few pleistocene remains and flint weapons from the cave floors, at Creswell Crags.

In the Magnesian Limestone near Welbeck Abbey, there exists a defile known as Creswell Crags, forming the border line between Nottinghamshire and Derbyshire, on the sides of which are several large fissures and cavernous recesses, which have been for years frequented by excursionists in search of romantic scenery. One of the larger caverns is named after Robin Hood.

During the last twelve months, by the kind permission of the Duke of Portland, the owner, an exploration has been going on, and is still being pursued, into the deposits which form the floors of the caves or block up the narrow fissures, and with results which are of importance from their scientific value.

The excavations have been, for the most part, carried out by Mr. Thomas Heath, curator of the Museum at Derby, and chiefly at the expense of a member of the Derby Museum and Library Committee. The Duke of Portland has rendered considerable assistance in permitting his quarrymen to blast the large rocks in the way of the excavations, and with labourers to carry the waste from the caverns.

Mr. Heath has already obtained a considerable number of bones, and weapons of stone and flint; and when these labours are completed there will be accumulated an extensive collection, nearly complete in its Peistocene fauna, and telling of the existence of Palæolithic stone-weapon people and of Neolithic-flint people in the same cavern, at consecutive periods of time.

The specimens I exhibit include the jaw of the old cave hyæna, with several teeth of younger ones; a lower molar of the tichorhine rhinoceros; teeth of reindeer and of the horse, not to be distinguished from the horses living at the present day; and two flint flakes, of the type so plentiful in the caves of Dordogne, France.

These bones and weapons occur in successive layers of deposits, in some sort of order, but there is no doubt that some of the deposits have been, at times, disturbed and re-deposited by floods from above getting into the caves and fissures; so that it is not altogether safe to be too positive upon the order of the occurrence of the bones, and prematurely draw deductions which may not be able to be held when the true history of the caves is understood.

The surface soil, when present, is of any thickness up to 18 inches, and in it are found articles, ancient and modern, Roman and other potteries, tobacco pipes, with bones of common sheep and pigs.

Below is a limestone breccia and cave earth, lying over a bed of sand, running about three feet deep, in which bones of animals and flint weapons have been plentifully found, and in which are big blocks of limestone, which had at the time of the deposition of the sand fallen from the roof. Underlying this is a deposit of light-coloured sand, hardened by the infiltration of the limey droppings from the roof, and this seems to lie directly on the limestone floor. The order here described is not perfect in all places, but it pretty well conveys the general character of the deposits.

These remains have been determined to be bones and teeth of the cave lion, grisly bear, brown bear, cave hyæna, wolf, glutton, arctic fox, Irish elk, reindeer, the mammoth, the tichorhine rhinoceros, a bison, and the extinct long-faced

ox, the common fox, horse, pig, goat, sheep, hare, and water vole.*

Professor DAWKINS said: I must say that I feel considerable astonishment at finding this communication brought before the Society, and for these reasons. The Duke of Portland has been kind enough to hand over the exploration of the whole group of caves at Creswell Crags, situated on his property, to the Rev. J. M. Mello, of Chesterfield, who first discovered these caves, and who has spent a considerable amount of time in working them out. He described one of the caves, named the Pin Hole, with the aid of Professor Busk, most completely, before the Geological Society of London, last spring, and during the past winter, in connection with Mr. Heath—for he called in Mr. Heath to assist him—a second, named the Robin Hood Cave. Mr. Mello has obtained from this cave one of the most remarkable collections of implements and of bones which has yet been found in this country, with the exception, perhaps, of that in Kent's Hole. The excavations are not completed. I have had an opportunity of examining all the remains which are in possession of Mr. Mello, and also the more important of those which Mr. Heath obtained for the Derby Museum, through the kindness of Mr. Mello. And—that gentleman having obtained from the Duke of Portland the sole right of excavating these caves—I feel greatly astonished at coming here and finding on the table a set of specimens which show that, however carefully and however minutely he may have conducted the exploration, and however carefully and however minutely those remains may have been interpreted, his record is incomplete. I think it my duty to say that it is a

* Papers by the Rev. J. M. Mello, Professor Busk, and Professor Dawkins, upon these discoveries, will be found in the Quart. Journ. Geo. Soc., Lon., Vols. 31, 32.

very serious mistake for any person to interfere with an excavation which is being carried on as admirably as Mr. Mello is carrying on this, and as he has carried it on from time to time since last July—an excavation, moreover, which is not in any degree complete. It is doubly hard when, in the account which has just been given of this cave, Mr. Mello's name is not even mentioned. Mr. Mello's paper must be fresh in the mind of everyone who reads the *Times*, or the *Pall Mall Gazette*, or, the *Colliery Guardian;* for it is only about a fortnight ago that Mr. Mello brought the results of his explorations before the Geological Society of London, and promised to continue them to the best of his ability. I think it my duty, though a very unpleasant one, to mention these facts.

FIRES IN COAL MINES.

Mr. Joseph Thompson, F.G.S., read a paper on "Fires in Coal Mines, and their Extinction:"—

Not the least important and serious of the various forms of danger to which the lives of underground workers, as well as the property of mine-owners, is exposed, is that arising from the occurrence of fires underground; for although in most cases such fires are attended with injury to the works of the mine more than loss of life, cases have occurred in more than one instance where lives have been sacrificed.

No doubt you are all as well aware as myself that these fires have several sources of origin. Thus, in the event of an explosion of fire damp, the coal may become ignited direct from the flame of the explosion, or the blaze may be communicated to the coal from burning brattice or timber. An inexperienced or careless collier, after firing his shot,

which (as not unfrequently happens) has lighted a feeder of gas, does not examine his place after the firing of the shot until the flame has attained serious proportions, and is difficult to subdue.

A badly planted shot may blow out and ignite the brattice, a negligent stoker at underground boilers may leave the ashes insufficiently damped, and various other contingencies may arise, all or any of which might account for the occurrence or existence of a fire.

These fires also not unfrequently originate spontaneously, owing to chemical decomposition, and occur not uncommonly at long distances from the shaft, and are, consequently, extremely difficult to control or extinguish, owing to the absence of suitable appliances.

In addition to the sources of underground fires which I have mentioned, I regret to think some have been the work of incendiarism.

Let the cause, however, be what it may, there is no doubt that the risk of fire, with its attendant difficulties, constitutes a constant menace to those persons who are responsible for the safe working of our mines, and into whose hands the custody of valuable property is given. Naturally, the thought which first occurs to any person on hearing of a fire is, as to what appliances there are at hand for throwing as bountiful a supply of water as is possible upon the flames, with the view by this means of extinguishing them; but below ground it not unfrequently happens that a sufficient supply of water cannot be obtained, or that, a sufficient supply being at hand, the circumstances of the case are such that that supply cannot be thrown to the points where it is most needed.

Steam, as well as carbonic acid gas, have, I believe, been tried in some mines as extinguishers, with more or less success; and an apparatus, called *l'Extincteur*, was used

very successfully, I believe, in the case of a mine which was on fire in the neighbourhood of Wigan, about two years ago. Yet, notwithstanding all these appliances, underground fires many times attain such proportions that these means are entirely ineffectual, and there is then no course open for attempting its extinction except that of isolating it from the atmosphere by building dams or stoppings across every point of access to the region of the fire, or by sealing the pit shafts. Let me qualify my remark, sealing the pit shafts, by saying that what I mean should be done is, that the downcast shaft should be close sealed, and the scaffold, on or in the upcast shaft, have a hole left in it covered by a valve so constructed as to admit the egress of the volume of vitiated atmosphere produced by expansion, due to the excessive heat within the mine, and also by atmospheric changes, but which valve closes up the hole automatically as soon as there is a tendency for the air above the scaffold to rush inwards. It often happens, however, that the work of building walls or dams in open places around the region of a fire is ineffectual, owing to the difficulty which is experienced in finding perfectly solid roof, floor, and sides against which to construct the dams or stoppings, as, in the event of there being any leakage at any point, combustion still goes on.

For this and possibly other reasons I think there is a tendency on the part of mining engineers and colliery managers to incline to the idea of sealing the shaft or shafts, as against the attempting of damming off the region of the fire, in cases where a fire has got the upper hand. I have heard of cases where no measures at all have been taken for extinction, and the fire has burnt on for a long period of years. But the value of mineral property is now so great, and especially in this country, that the unfortunate owners of any sealed-up mine are, I think, almost invariably

very anxious to have their mines re-opened as soon as is possible, consistent with a due regard to safety.

It is impossible for any person to define what length of time is sufficient to be allowed to elapse before it is safe to re-admit fresh air and enter the mine. I hardly need mention that cases are on record where the re-opening has been commenced too precipitately, and sorrowful and disastrous consequences have issued.

It will, therefore, be clear that the operation of re-opening a mine which has been on fire is one not unattended with considerable difficulty and risk, and any scheme which may be adopted for re-opening should first be very carefully matured.

Having in view the opinion expressed at our meeting held on the 25th of January last, to the effect that the Society would be glad to have papers read on subjects bearing on practical mining, I have ventured to think that a short and necessarily imperfect account of a fire which occurred at the Norley Colliery, near Wigan—the work of combating which, as well as the sealing up of the shafts and the re-opening thereof, was carried out under my supervision—might not be uninteresting.

There is not much to interest in reference to the cause of the fire which to this day remains practically a mystery, nor in respect to the sealing of the shafts, the most important feature in the case being the manner in which the re-opening was effected and access to the workings obtained.

Still I think it will help you to understand my explanation of the re-opening better, if I first explain, briefly, the position of the shafts and workings and the seat of the fire.

As I have just observed, this fire occurred at the Norley Colliery, near Wigan, during the night of the 10th or

morning of the 11th December, 1872, in what is known as the Orrell 5 feet mine, in No. 3 Pit, at that colliery.

Referring to plan and section, it will be seen that the Orrell 5 feet mine is about 65 yards above the Orrell 4 feet, or Arley Mine, and about the same distance below the Yard Coal Mine, the Orrell 4 feet being at a depth of 508 yards.

Running in a nearly northerly and southerly direction, about 200 yards to the east of the pits, is a downthrow fault to west of about 43 yards, which causes the Arley, or Orrell 4 feet mine, on the east side, to be nearly opposite the Orrell 5 feet mine on the west side, and the like with the Orrell 5 feet and Yard Coal Mines.

Dip tunnels have been driven through this fault from both the Yard mine and the Orrell 5 feet mine respectively to the Orrell 5 feet and the Orrell 4 feet mines on the east side, and a ladder pit has also been made, in which there is a wire rope and chain ladder along a fault vein from the Orrell 5 feet downwards to the Orrell 4 feet mine (as shown on plan and section at the points marked A). The fire originated in or near to an underground hauling engine-house, situate at the point (marked B on plan and section) near to the bottom of No. 3, or downcast shaft, in the main intake air-way, where a strong current of fresh air was constantly passing, materially assisting the fire in its course, during which it burnt away all the timber supports of the roof, which subsequently fell, rendering extremely difficult and dangerous the efforts made to extinguish it by means of jets of water.

Preparations were then commenced for isolating the fire from the fresh air by means of dams or stoppings, as previously referred to; but the difficulty which I mentioned, viz., that of finding absolutely compact roof, floor, and sides against which to construct the dams or stoppings, was experienced; and as the fire was continually and rapidly

increasing in intensity, and was now of a most formidable character, it was decided at once to seal up the downcast shaft, at a short distance below the mouthing of the Yard Coal (as shown on section, at point marked C). The sealing of this shaft was effected by means of two scaffolds, consisting in each case of two layers of 3-inch planks, reposing on huge oak bearers, the first or lowest scaffold having three feet thick of puddle on the top of the planks, and a foot deep of water on the top of the clay.

The second or topmost scaffold was similar to the first, with the exception that just above the planks the pit walling and the backing were removed a brick and a half deep, and puddle well rammed against the natural strata behind. A 5-inch cast-iron pipe was put through both these scaffolds when they were constructed, in which was a valve immediately above the higher scaffold; and four or five feet below the top end of the pipe, which had a close-fitting lid, through the top of which was a small hole, to admit of the passage of a string, to which the thermometer was attached, for taking observations in this shaft.

It will, therefore, be seen that observations of temperature could by this means be taken without admitting any material quantity of cold air, so that those observations could not be influenced by anything from the outside, as, when the valve was open, the close-fitting lid was on, and *vice versa*, the valve being always closed except when observations were being made. A single scaffold covering was next put over the upcast shaft, at the point where the smaller shaft from the lower mines enters the main upcast or No. 2 shaft, *i.e.*, at the Cannel mine (marked D on section).

In this scaffold a hole about six inches square was left, which was covered by a hinged flap-valve, which yielded to the pressure from within, but closed immediately there was pressure from without. By this means the workings of the

pit got relief of the pressure produced by expansion within the mine, as well as to pressure outwards due to a falling barometer.

Three wall stoppings in the approaches to the ladder pit (at point A on plan and section) completed the sealing off entirely, and arrangements took effect for recording frequently the temperatures in both the downcast and the upcast pits.

The result of these observations may be stated in a few words.

Thus, taking the downcast pit first, the highest observations taken by the thermometer opposite the seat of the fire at the Orrell 5 feet mouthing were as follows :—

1873. January 7th.—89° Fahr. was read. January 10th. —After having been down to 81°, a reading of 87° was taken on the 28th January, when the temperature again lowered to 79° on February 1st, on which day increased temperature was observed, which continued till February 6th, on which date 85° was indicated. By the 8th, however, the indications got back to 80°, which continued till February 27th, when some slight fluctuations took place of no importance. From March 10th to 18th, uniform readings of 79° were taken, when some disturbance was indicated, and the temperature went up irregularly till 81° was reached, on May 26th, 1873, from which date a gradual fall occurred, and on June 28th the reading was again 78°, same as on May 15th. This cooling seems to have continued until the time at which the operations for re-opening commenced, when the thermometer indicated 76° Fahr. Throughout the whole time during which the pits were closed the temperature immediately below the scaffold was a few degrees lower than opposite the Orrell 5 feet mouthing, their variations being uniform.

I attribute the higher readings referred to as having occurred between May 23rd and June 28th, to disturbance caused by falling roof within the mine, as I am quite sure the observations of temperature made in the shaft opposite the seat of the fire were much below what would have been indicated in the workings, had it been possible to make any observations there. I am convinced of this by the fact that, after access had been obtained to the mine, and ribbings being driven alongside the falls in the old roadways, I got readings as high as 87° on the fallen roof, while in the new roadway the temperature—until we thoroughly restored the ventilation—was about 4° higher than before we opened the shaft. I therefore consider it very doubtful how far indications made under such conditions as these are to be taken as a criterion of what is going on in the workings of a mine, hence the very great uncertainty and danger which must necessarily attach to all operations for re-entering a mine which has been sealed up through fire.

If I am correctly informed, the thermometer gave a reading lower than any which I obtained at Norley, on the day on which the second explosion occurred at the Moss Pit at Ince, which displaced the whole of the sealing scaffolds, and rendered it necessary to flood the mines at once.

The temperature at Norley, in the upcast shaft, as nearly opposite the Orrell 5 feet mouthing as could be estimated, ranged about 88° to 90°, or several degrees higher than the downcast; but it must be remembered that previous to the occurrence of the fire a large ventilating furnace had for many years been discharging heat into this shaft, which would cause the brick casing of the shaft and the adjacent strata to be at a high temperature, and I therefore consider that no reliable deduction could be made from its temperature indications as to what was going on within the workings.

I therefore assume that, when it was determined to re-open this pit, there was no possibility of knowing whether or not the fire was, or was not, extinguished, and the serious apprehensions entertained by most people who were concerned in the work are easily justifiable.

Various schemes were discussed, but ultimately it was decided to approach the workings somewhat by stealth, or as one of my friends (I think Mr. Dickinson) said "feeling the pulse first." This feeling the pulse operation I shall now describe.

Referring to plan at the point (marked A) which is at the ladder pit, it will be seen that there is an almost direct course from the bottom of it over the seat of the fire across the downcast shaft to the upcast, and any atmospheric air admitted at that point before it can get to the upcast must necessarily pass over the seat of the fire, therefore a thermometer hung opposite the Orrell 5ft. mouthing in the No. 3 or downcast shaft would indicate at once any variation of temperature, due either to the passage of the air admitted without encountering fire, or to the removal of heat from any fire smouldering or otherwise, which might be in existence on its route.

The course adopted was to erect a long wooden box, one end of which was passed through the stopping doors near the top of the ladder pit (marked D D on section), the other end projecting a number of feet outside the outer doors. Near the outer door an iron slide was fixed in this wooden box or pipe by means of which the quantity of air admitted could be regulated at discretion, being measured by one of Mr. Casartelli's air meters, (which indicates up to ten millions of revolutions,) placed near the outer end of the box or pipe in which glass windows were made opposite the position of the air meter to enable observations to be made.

An electric signal telegraph was constructed, between the two points A and C, so that signals could be exchanged during the operations, and that in the event of adverse indications on the thermometers in the shafts the admission of air might be made to cease at once and the men withdrawn.

The signals were made by a certain number of gongs given either way. Thus: one gong given from either end to the other indicated "all right," and given on receipt of any other signal or message means "I do understand." Two gongs given in reply by either end to the other on receipt of a message indicated "I do not understand." Other signals were arranged by which the admission of air could be increased or decreased at pleasure, the running of the current through the inlet reported, and, if necessary, the men ordered to withdraw from the mine. One staff of men was placed at point A, to regulate the admission of air by means of the iron shutter or slide in accordance with instructions they would receive through the telegraph; another staff was at point C, to take the temperatures in downcast periodically and to exchange the "all right" signal every three minutes with the other men at point A.

Another staff of men was placed at the top of the upcast bye pit in the Cannel mine, to watch the small hole previously referred to as having been left in the scaffold at that point, and to take temperatures.

I do not see in what way the long list of temperatures and quantities of air admitted would be of any service, and I have therefore only to add that we carried on our work unceasingly day and night until we passed fresh cool air through the small hole in the scaffold in the upcast pit, the same having passed over the seat of the fire and through what before the accident had been a hot boiler-house.

We now considered that we had "felt the pulse," and, as

rapidly as possible, took out the scaffolds in the downcast shaft and explored the mine with success.

I have never been able to discover what was the origin of the fire, and I am therefore unable to establish any recommendation for the avoidance of similar calamities in the future.

I cannot close this paper without expressing my appreciation of the very kind and friendly advice and assistance which I received on several occasions from Mr. Dickinson, as well as from Mr. James Beaumont, of Oughtibridge, near Sheffield, as well as of the great value of the services which my underground officials rendered in this emergency.

Mr. J. E. Forbes proposed, and Mr. C. Hardwick seconded, a vote of thanks to Mr. Thompson for his valuable communication.

Mr. John Knowles said that his firm had had experience, at various times, in respect to fires. Their system, however, of extinguishing a fire differed from that of Mr. Thompson. They tried to get to the seat of the fire, as soon as possible, and to make it off at the nearest point—invariably at the intake—so that any heat arising from it might gradually pass away. They had a fire at Agecroft some years ago, at the Rams Mine, and in that case by closing the intake for three or four months, and allowing the return to be open, it went out. The most serious fire they had had of late years was in 1866, at their Pendlebury Colliery. He read a paper to the Society some time after its occurrence.* In that case he believed the mischief originated through one of the men setting the brattice on fire and leaving it. It took about a fortnight to master that. They prepared to build it off, in the event of not being able to master it by water. Small fire engines were employed to get water to the place; and

he thought that at every colliery it might be advisable to have a small fire engine fitted on a waggon—as they had now—ready to take to any part of the pit. By having the hose of sufficient length water could be poured upon the fire immediately, and with greater effect than by the old plan of taking it in buckets. The creation of steam prevented any rapid spread of the fire.

Mr. FLETCHER said they had a fire at the Atherton Colliery, which commenced last May, and their experience was just the same as Mr. Knowles's. He observed the wonderful way in which the fire travelled backwards towards the fresh air. They attempted, for about a week, to put out the fire with water, and would doubtless have succeeded but for frequent falls of roof liberating gas and causing explosions. As it was, they had to resort to the usual expedient of building stoppings, and making it off. The place was opened out at the beginning of last month, having been shut off ten months, and they found the fire entirely out. If they had been able to continue the use of water they would very soon have mastered it, but the explosions of gas made it dangerous.

Mr. THOMPSON said he could bear out what Mr. Fletcher had stated with regard to the working back of the flame. It did exactly the same at the Norley Colliery. There, it set back to within ten or a dozen yards of the shaft, though, when the mine was re-entered, the seat of the fire was found to have been 180 yards away.

Mr. FLETCHER said that, in their case, the fire travelled back about 30 yards in eight or nine hours.

Mr. DICKINSON said that Mr. Thompson had given so fully the particulars of the Norley fire that he could add nothing to what that gentleman had said, except, perhaps, that he had not made it quite clear that the mine, when shut off, was filled with fire damp. The danger in sending

a current of air through the mine—what was called "feeling the pulse"—was, lest, by that means an explosive mixture should be formed likely to get ignited at the fire.

Mr. MARTIN said that at a colliery with which he was formerly connected in Germany, a fire occurred in the return air course, which, owing to the dryness of the place, extended 150 yards in three quarters of an hour. In that case the fire was first shut off; subsequently the shaft was closed for a fortnight or three weeks; and when examined, the fire was still found to be burning. Water was carried down in tubs, and the flame extinguished throughout the entire length that it had extended,—220 yards. In that case the fire had extended more into the roof than into the coal. The coal was coked and charred in many places to a depth of 8 or 9 inches, but in the roof the fire had taken effect to a depth of 12 or 15 inches. They were obliged to suspend work for some time, but were fortunate in being near the upcast shaft—it being one of the main returns—so that, with the ventilation, they had experienced little difficulty, although at times the men were overcome. The use of water was found to be very effective.

After some observations from Mr. Woodward,

Mr. TONGE mentioned that in the case of a fire at the Hulton Colliery, water was carried down and thrown upon the fire by means of hose. Unfortunately, however, the smoke got upon the wrong side of the men who were playing upon the fire—that was, got between the men and the shaft—and they were compelled to leave off. They had the hose attached to pumps. Having failed in that, they turned a large quantity of water into the shaft. In a few days the shaft was re-opened, and the water pumped out; and the fire was found to be extinguished.

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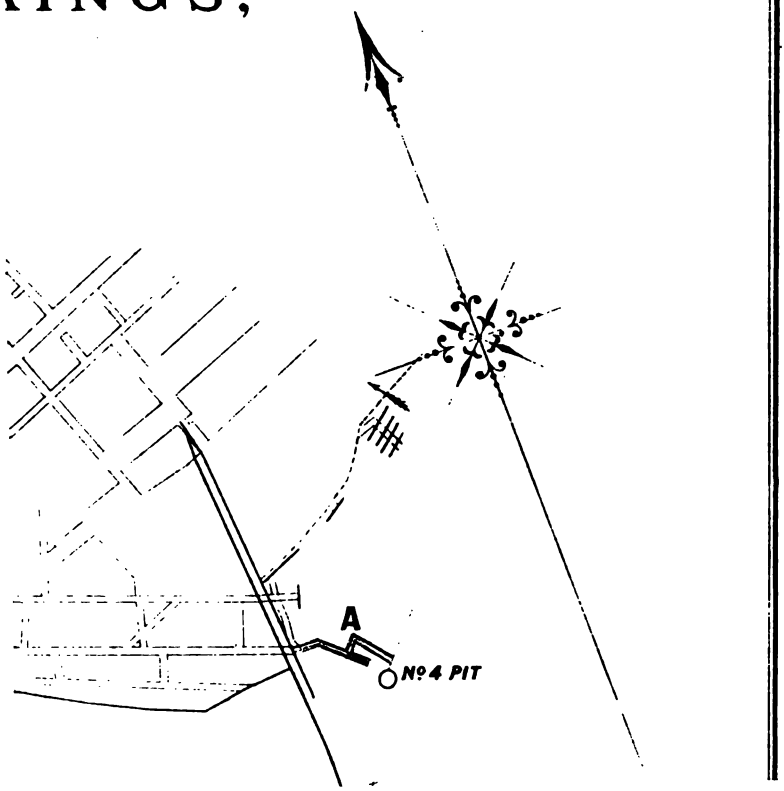
* Trans. Man. Geo. Soc., Vol. xii., No. 2.

Mr. PILKINGTON said that, wherever possible, it was undoubtedly best to get at the seat of the fire, and throw water upon it.

The discussion was continued by Mr. TRAICE and Mr. GRIMSHAW, the latter gentleman stating that a fire had occurred in his experience, which differed somewhat from the cases mentioned by previous speakers. At about 14 yards above the furnace was a mouthing, and the framework and coal, by some means, caught fire from the furnace. The fire spread up the pit, giving out such an intense heat that the metals in the pit were liquified, and they flowed down forming a perfect barrier between the air-way above the furnace and the pit top. The works, of course, were all stopped. A small tunnel was driven above the seat of the fire, for immediate use as an air-road: then water was turned down the pit, and after a good deal of trouble the fire was got out. He had been down to the barrier in the pit; it seemed a perfectly solid mass of metal, 5 feet thick; and weights, varying from 5 to 15 cwt. were dropped upon it from the top of the pit without producing any effect. It could not be moved. The pit beneath it was therefore filled up, and the air-roads were taken over it.

The discussion then closed.

KINGS,



others also, from the correspondence which has [illegible]

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART 4. VOL. XIV. SESSION 1875-6.

At the ORDINARY MEETING of the Society, held on Tuesday, 30th May, 1876.

Mr. JOSEPH DICKINSON (Vice-President), F.G.S., Her Majesty's Inspector of Mines, in the Chair.

The CHAIRMAN said that the whole of the Geological Survey Maps of Lancashire, both the one and six-inch scale and the section maps of Lancashire, had now been received by the Society, and were now in the library, where members could have access to them. The Council had also received several reports of the Geological Survey of the United States, which, with other books, had been presented to the Society.

THE CRESWELL CAVES.

The CHAIRMAN said the paper to be read at the present meeting was, "On the Exploration of the Caves at Creswell Crags," by the Rev. J. Magens Mello, M.A., F.G.S., and Mr. Thomas Heath, F.R.H.S. Those members who were present at the last meeting would be aware—and perhaps others also, from the correspondence which had since

appeared in the newspapers—that Mr. Plant brought the subject of the Creswell discoveries before the Society at that meeting, and that exception was taken to his communication by Professor Dawkins on two grounds: First, that the exploration of the caves in question had been entrusted to the Rev. Mr. Mello, of Chesterfield, by whom they were first discovered, and who had spent a considerable amount of time in working them out; and that in the work of exploration he had the assistance of Mr. Heath. Secondly, Professor Dawkins thought it was doubly hard that Mr. Mello, who had, as before stated, conducted the exploration, should have been entirely ignored in Mr. Plant's communication. He (Mr. Dickinson) observed that, since the meeting, Mr. Plant's paper had been printed in the Society's Transactions, and that, in a foot-note, he had supplied the principal ground of objection which Mr. Dawkins brought before the meeting. It was not, perhaps, desirable that any further discussion should take place on that specific point; but it was desirable, when any paper was brought before the society, and there was any omission on the part of the author—which omission was strongly animadverted on by another member—that the author should not have the opportunity of taking the wind out of his sails, by supplying in print what he failed to bring before the meeting, unless accompanied by a proper explanation.

Professor Boyd Dawkins said that the paper placed in his hands by the Rev. J. Magens Mello and Mr. Heath bore relation to some of those remarks which were made at the last meeting of the Society—on which, of course, the members who were present at that meeting could form their own opinion—and it was only fair to Mr. Mello and Mr. Heath that what they had to say in regard to the Creswell discoveries should be brought before the Society. He (Professor Dawkins) therefore offered to read any communication which

they thought fit to send, because he thought it was really a matter of vital importance to the Society's interests. The paper was as follows:—

ON THE EXPLORATION OF CRESWELL CRAGS CAVES.

By the Rev. J. Magens Mello, M.A., F.G.S., &c.,
And Thomas Heath, F.R.H.S.

In the spring of 1875, the first-named of the authors of this paper formed the wish to explore the caves of Creswell Crags, little doubting that they would yield results of considerable value, and throw perhaps some additional light upon the records of the Pleistocene and later ages of geological and human history. This wish was speedily carried into effect, and the first visit sufficed to show that a thorough exploration was desirable. Permission was then immediately sought from the Duke of Portland, who most kindly at once granted the right of pursuing the discovery, and has since placed every facility at his disposal.

The ravine of Creswell Crags, on the north-eastern boundary of Derbyshire, runs from west to east, being formed by low cliffs of the massive lower magnesian limestone. These are about 50 feet or 60 feet high in places, and are beautifully wooded. The permian limestone here is very hard, and is much fissured; the fissures in several instances forming tolerable sized caves. There are some four or five of these on the northern side of the ravine, and one or two on the other. The principal ones, however, are, with one exception, on the northern or Derbyshire side. The cavern first explored was one called the Pin Hole, from a strange custom of visitors dropping a pin into a small hollow in a rock, and taking out one deposited by a previous

visitor. What the origin of this custom is we cannot tell, but it is said that a somewhat similar one is known at a place in Ireland, and also in Devonshire.

The Pin Hole Cave is a mere fissure, with a moderately wide entrance. It penetrates some 40 or 50 yards into the hill side, running nearly magnetic north, and it is almost horizontal throughout its entire length. It is moderately lofty for the greater part of its course, but a very short distance from its entrance it bifurcates, and becomes extremely narrow, the right hand branch being the only one that is accessible for any distance. At several points there are to be seen some large masses of rock which have slipped, and have become wedged between the roof and the floor. The cave also contains a good deal of stalactite in the roof, but the floor itself is, as far as it has been examined, very free from either stalagmite or breccia. The floor of the Pin Hole Cave is one of the very simplest description, consisting of a thin crust of recent surface soil, no cave earth, such as will be described in connection with an adjoining cavern, but beneath the surface layer there is a bed of red sand, which contained a large number of bones, and which is succeeded by a bed of lighter coloured sand, consolidated by calcareous infiltration, and destitute of fossil remains. The work of exploring the Pin Hole was a mere matter of careful digging, all the front portion of the fissure being cleared out layer by layer. The red sand bed, which was some three feet thick, yielded a very large number of bones of the characteristic Pleistocene fauna. They were frequently found matted together, four or five bones of different animals in some instances lying in close contact. There is little doubt, from the general arrangement of the bones in this bed, as well as from the presence of some fish remains, consisting of both scales and vertebræ, that since the contents of the cave were first brought in they have been partly

shifted and re-arranged by water, perhaps by the flooding of the stream which now runs so insignificantly through the dale, but which in the Pleistocene period probably ran in greater volume and at a somewhat higher level. There was hardly a trace of human occupation to be found in the Pin Hole, one flint implement alone, a few inches below the surface, being the sole token of man's presence in early times in this cave, but the list of animals found here is both extensive and important. These are:—

Ursus sp?	Bear.
Gulo luscus	Glutton.
Canis vulpes	Fox.
,, lupus	Wolf.
,, lagopus	Arctic fox.
Hyæna spelæa	Hyæna.
Cervus megaceros	Irish elk.
,, tarandus	Reindeer.
Bos primigenius	Urus.
Equus caballus	Horn.
Rhinoceros tichorhinus	Woolly rhinoceros.
Elephas primigenius	Mammoth.
Lepus timidus	Hare.
Arvicola amphibius	Water vole.
A Bird sp?	
Fish sp?	

Of these the most noteworthy are the glutton and the Arctic fox, the former of these is still found in Siberia and in North America, it is the same animal as the wolverine of the American fur hunters. The glutton has been found only three times in British caves, before its discovery at Creswell, but it has been found, together with the Arctic fox in considerable numbers in Belgium. The discovery of the Arctic fox at Creswell is the first recorded find of its remains in Great Britain. The other animals call for no particular remarks, save that the wolf remains obtained

from the Pin Hole, are said by Professor Busk, who kindly examined the bones from this cave, to resemble rather the Arctic or American species than the existing European wolf; if this be so, then it would have been a fitting companion for such animals as those just mentioned, and of the reindeer and other species whose presence is significative of a far severer climate than that now prevailing in these islands. The second cave examined at Creswell is that known as Robin Hood's, it is situated a little lower down the ravine than the Pin Hole, and similar Pleistocene remains to those of that cave, and also flint and quartzite implements having been found in its floor in the course of a preliminary search in May, it was resolved that a thorough exploration of its contents should be made as soon as that at the other cave was completed; and in July the authors of this paper, the second of whom then had sought permission to take part in the work, began to explore it conjointly. The interpretation of the human and animal remains was entrusted to Professor Boyd Dawkins, and the results up to the close of the year were laid before the Geological Society of London. Robin Hood's Cave differs both in character and also in some important respects in its contents from the Pin Hole. It is much wider and more accessible, and is divided in its interior into several chambers formed by buttresses of rock springing from the back, the length of the cavern is not great being only about 30 yards, and it is nearly as broad as it is long. On the right side the roof is tolerably lofty, but on the left hand it is extremely low, and at one or two points it was united to the floor by stalagmite. A few small fissures run into the rock from the sides of the cavern. The floor of this cavern is more complicated than that of the former one. A general section showing first more or less of recent surface accumulation, which however, is nowhere of any

greater thickness than an inch or two at the most. This was followed on the left hand side of the cavern by an extremely hard limestone breccia, as much as 3 feet thick in part, but thinning away towards the right hand side of the cave, and near the centre of the entrance there was no breccia. The breccia is succeeded by a thickish deposit of cave earth, varying in thickness inversely as regards the breccia from about 3 feet to as many inches. Below the cave earth was a bed of red sand similar in character to that of the Pin Hole, and this rested on a lighter sand full of loose limestone, evidently close to the original floor of the cave, this was found near the entrance at a depth of about 5 feet, but further in the thickness of the deposits was greater.

In all the beds of Robin Hood's Cave, except the bottom-most, organic remains have been found. The general character of the fauna of both caves is identical, being most unmistakably Pleistocene, and belonging to that age when the severity of an almost Arctic climate yet prevailed in this country during the winter. As to the distribution of animal remains in these caves it may be observed that one or two species found in the Pin Hole have not as yet been discovered in Robin Hood's Cave, which on the other hand has yielded some animals absent from the former. The most striking difference is found in the orderly succession of the deposits in Robin Hood's Cave, which in conjunction with the numerous traces of human occupation during the Pleistocene period, give to it an exceptional importance in the history of "cave hunting." That signs of man's presence should be found rather in this cave than the other is natural enough; the larger and more commodious cave would certainly have been preferred by the early inhabitants of the district for a home or a sheltering place to the narrow fissure.

Looking now at the sequence of the beds in Robin Hood's Cave and their contents, the surface soil yielded nothing of interest save a few broken fragments of rather late Mediæval pottery and a few of Roman pottery. Amongst the latter was a small piece of coarse Samian ware. Beneath the surface soil, over a large extent of the cave, we come to the bed of limestone breccia, of variable thickness. This, which was intensely hard, had to be broken up by frequent blasting. It was found to contain bones, mostly of the same Pleistocene species which occur in the succeeding deposits; remains of animals of a later age being but few, and near the top. In the breccia occur teeth and bones of the bear, the fox, the hare, the reindeer, the hyæna, and the woolly rhinoceros and horse. Together with these were found numerous flint implements, mostly chips and flakes; but some few of them were carefully wrought lanceolate weapons, trimmed on either side, and approaching in character the typical forms from Solutré and some other French caves, as well as from some in Belgium. The cave earth below the breccia contained the relics of a similar fauna, with one or two additions, but a different type of implements was met with. There were still found chips of flint and a few flakes, but none presenting the more elaborately shaped forms of those of the breccia. And, in addition to the implements of flint, there were found one or two of bone, and there were also numerous rudely fashioned ones of quartzite, &c., roughly made from water-worn pebbles. Some of these were rather more carefully trimmed than others, being chipped on both faces. Their forms were oval for the most part. There were also one or two pebbles that had evidently been used as hammers, showing bruised faces. These implements of quartzite were, with but one or two exceptions, found only in the cave earth, the exceptions being two or three which occurred in the lower part of the breccia. It has been

pointed out by Professor Dawkins that the type of the cave earth implements is that of an earlier period than that of those of the breccia, and resembles that of the river gravel implements and of those from the lowest strata in Kent's Hole, as well as of those obtained from continental caves of the Moustiers' epoch.

The red sand bed next in succession to the cave earth in Robin Hood's Cave was entirely destitute of any traces of man, but contained bones of most of the animals already met with, some of the most abundant being those of the bison. No bones have as yet been found underlying this bed. The following is a list of the mammalian inhabitants of Robin Hood's Cave, found below the uppermost part of the breccia:—

Homo.
Felis leo, var spelæa.
Hyæna spelæa.
Canis vulpes.
,, lupus.
Ursus ferox.
,, Arctos.
Cervus megaceros.
Cervus tarandus.
Bison priscus.
Equus caballus.
Rhinoceros tichorhinus.
Elephas primigenius.
Sus scrofa.
Lepus timidus.

In the surface soil and in the upper part of the breccia there occurred some bones of the domestic hog, the dog, goat, sheep, and Celtic short horn; but no implements of a Neolithic type were found associated with these. In fact, Neolithic man is as far as we have yet learnt from these caves altogether unrepresented in them. From Roman times we pass at once into the remote Palæolithic past, two stages of which seem to be here before us, when man the hunter and fisherman endured all the vicissitudes of a climate at one time mild enough for the hippopotamus to be an occupant of the Yorkshire rivers; at another so severe that amid the snow and ice of an Arctic winter, he would

have to struggle for existence in company with the reindeer, the glutton, and the Arctic fox; and doubtless contend at times with more formidable opponents, who like himself roamed amid the forests of this part of England, and found at any rate an occasional home in the caves of Creswell Crags.

On the motion of Mr. J. E. FORBES, seconded by Mr. GREENWELL, a vote of thanks was given to Professor Dawkins for his communication.

Professor DAWKINS called the attention of the meeting to specimens of bones, &c., on the table, illustrative of the paper which he had read. Among the specimens were several examples of flint flakes.

Mr. AITKEN said he understood, from the paper, that Neolithic man was not represented at all in the Robin Hood Cave, and that these implements are confined to the Palæolithic period. Do the flint scrapers belong to that period? They so closely resemble those attributed to the Neolithic age that, in glancing over them, I should not have hesitated to attribute them to that period myself.

Professor DAWKINS said that one flake was so much like another that it was impossible to tell whether a piece of flint such as the one exhibited, with a cutting edge, belonged to the Neolithic, Palæolithic, or Roman ages. These implements were associated with remains of extinct animals in well-defined strata; all of them. There were no traces whatever of Neolithic implements properly so called, nor in any of the caves had there been found, as yet, the smallest proof of the presence of Neolithic man. Flakes of this kind—he meant rude and rough splinters of flint—were found very widely distributed. He had himself found such flakes in association with Roman remains at Pulborough, in

Sussex. He took several of them out of a Roman coffin, into which they had been put for some unknown purpose; and Colonel Lane-Fox had met with similar flakes also in association with Roman remains in Kent.

The following specimens were exhibited by Professor DAWKINS:—A series of fossil remains of wild animals and of Palæolithic implements from the caves at Creswell.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART V. VOL. XIV. SESSION 1876-7.

ANNUAL MEETING.

The ANNUAL MEETING of the Members of the Society was held on Tuesday, the 31st October, in the Literary and Philosophical Society's Rooms, George Street, Manchester. Mr. JOSEPH DICKINSON, F.G.S., Vice-President, in the chair.

The following Report of the Council was read by Mr. J. E. Forbes, F.G.S., Honorary Secretary:—

REPORT OF THE COUNCIL FOR 1875-6.

The Council of the Manchester Geological Society beg to report to the Members, that as far as concerns the material condition of the Society, in respect to its body of Members and finances, it is in a satisfactory state. The number of Members, after balancing the gains against the losses during the year, is practically unaltered from that of last year, whilst the invested fund has been increased to £600., owing, however, to a heavier expenditure than usual, arising chiefly from the principal cost of printing in the preceding year being included in this year's bills, and the exceptional cost of new books and of the 6-inch Geological maps of Lancashire, the outlay has exceeded the income, leaving a small balance due to the Treasurer.

The Council feel sure the Society will concur with them that it is desirable to increase the Library as far as the funds will allow, by the purchase of standard works on Geological

and Mining Science, and, especially on maps which throw any information on the geology of Lancashire and Cheshire.

The Library has lately been growing so fast that the Council for the coming session will be necessitated to provide additional bookcases.

The sale of the transactions has not been great, so that the stock in hand remains about the same. The additions consisting of the stock of the parts issued during the year, *i.e.*, parts 1, 2, 3, and 4 of volume 14. The Council believe that part of the large stock of the earliest transactions might be advantageously sold.

The Council regret very much that they are not able to report to the members as favourably of the ordinary meetings in the session as was fortunately the case with their predecessors in 1875. It has frequently been complained of that members do not render the Council that support which is essential to the life and vigour of a scientific body, pursuing and studying a science both with a practical and commercial, as well as with an intellectual object.

The Council cannot believe that they are exceeding their proper duty if they revert to the very favourable circumstances, both in the condition and in the locality of the Society, which have nearly all the conditions that ought to conduce to a more active state of scientific inquiry and work amongst its members. It is well-known that many members are in an excellent position to be able to contribute papers to the meetings, embracing their personal observations and practically acquired knowledge, both in mining and geological matters, and the Council make an earnest appeal to those members who are engaged in the management and working of the coal and iron mines in South Lancashire—one of the busiest districts in the mining world—to give their attention to the claims of the Society, and aid the Council to provide papers of interest for the meetings of the

members, so that the occasion, which they have at present to lament, may not recur at the future meetings of the members.

The Council regret that, from circumstances of an urgent nature in business, the meetings of the members were held without the presence of the President upon any one occasion; and they still more have to regret that, out of the nine meetings held during the session, at several of them neither papers nor subjects for discussion were presented—even in sciences so fertile in new discoveries and theoretical views as Geology and Mining.

In the last report the Council felt it necessary to draw attention to the action of "The Senate of The Owens College" in their manner of carrying out "the articles of agreement" between the Geological Society and the Trustees to whom the Geological collection was transferred for presentation to The Owens College. The Council, as the successors of the original donors, feel it their duty to see that the conditions as to the right of admission for the members and for the public to the Geological Museum at The Owens College be fairly carried out by "The Senate of The Owens College." Yet the Council regret to find that in the calendar for 1876-77 of The Owens College the stated conditions for gaining admission to the Museum are neither in spirit, or to the letter, in accordance with the 5th clause of the original agreement; and they feel it necessary to remonstrate against the restrictions which are sought to be imposed upon the members of this Society in respect to their guaranteed rights of admission to the Museum "for themselves and their friends," as they formerly enjoyed when the Museum was their own in Peter Street.

The Council trust that their successors will not lose sight of this important question, and be able to report at the next meeting that a proper rendering of "the agreement" has been adopted by The Owens College.

Dr. MANCHESTER GEOLOGICAL SOCIETY, BALANCE SHEET. Cr.

Abstract of Receipts.

1875.	£	s.	d.
To Balance brought down	44	11	6
,, Bank Interest	0	14	10
,, Birkenhead Dividends	23	16	0
,, Sale of Proceedings	1	6	6
,, Subscriptions and Arrears.....	93	10	0
,, Balance due to Treasurer	31	17	2
	£195	16	0

The Investments consist of £600. Four per cent. Guaranteed Stock of the Chester and Birkenhead Railway, in the names of Henry Mere Ormerod and Andrew Knowles.

Abstract of Payments.

1875.	£	s.	d.
By Library.....	33	11	11
,, Reporters	9	9	0
,, Transactions, Reports, &c.....	103	0	9
,, Postages, &c.	13	8	10
,, Collector's Commission	4	13	6
,, Rent.....	30	0	0
,, Tin Box for Maps	1	12	0
	£195	16	0
By Balance brought down	31	17	2

HENRY M. ORMEROD, Treasurer.

19th October, 1876.

NEW ORDINARY MEMBERS.

Cunliffe, P. G., Handforth.
Higson, John, 98, Albert Square.
Peace, George, Eccles.
Thompson, Joseph, Norley, Wigan.
Traice, W. H. J., Pendleton.
Woodward, H. A., Clifton.

DECEASED.

Brongniart, Adolphe.

RESIGNED.

Brierley, Joseph.
Eccles, James.
Gun, Captain H. A.
Traice, W. H. J.
Webster, R. C.
Woods, Henry.

THE FOLLOWING PAPERS AND COMMUNICATIONS HAVE BEEN BROUGHT BEFORE THE ORDINARY MEETINGS DURING THE SESSION.

1875.

Oct. 26. Annual Meeting.

Nov. 30. "Stigmaria Ficoides" in the Coal of Leinster, Ireland, by Mr. J. Dickinson.

"Age of the New South Wales Coal Beds," by Professor Dawkins.

Dec. 31. "On Measuring Air in Mines," by Mr. Joseph Dickinson.

1876.

Jan. 25. "On Drift Deposits on the Western Pennine Slopes of the upper drainage of the Rivers Calder and Irwell," by Mr. John Aitken.

"On a submerged Forest, near Holmfirth," by Mr. John Plant.

"Vivianite from Peat, at Barton-on-Irwell," by Mr. J. Plant.

Feb. 29. "On the Sub-Wealden Exploration," by Professor Dawkins.

"On Explosions in Mines," by Mr. G. C. Greenwell.

Mar. 24. No Paper.

April 25. "Discoveries at Creswell Crags," by Mr. John Plant.

"On Fires in Coal Mines," by Mr. Joseph Thompson.

May 27. "On the Exploration of Creswell Crags Caves," by Rev. J. M. Mello and Mr. Thomas Heath.

The Report was adopted and ordered to be printed.

The following gentlemen were then proposed and seconded, and declared duly elected as Officers and Members of the Council for the ensuing year :—

President.

PROFESSOR W. BOYD DAWKINS, F.R.S., F.G.S.

Vice-Presidents.

HON. A. EGERTON, M.P.
LORD GERARD, of Bryn.
OLIVER HEYWOOD.
G. FEREDAY SMITH, F.G.S.

Ex officio Vice-Presidents.

JAMES HEYWOOD, F.R.S.
G. W. ORMEROD, F.G.S.
E. W. BINNEY, F.R.S.
SIR J. P. KAY SHUTTLEWORTH, BART.
JOS. DICKINSON, F.G.S.
ANDREW KNOWLES.
G. C. GREENWELL, F.G.S.
JOHN AITKEN, F.G.S.
JOHN KNOWLES, M.I.C.E.
THOMAS KNOWLES, M.P.
W. BOYD DAWKINS, F.R.S.
CLIFFORD SMITH, F.G.S.

Treasurer.

HENRY MERE ORMEROD, F.G.S.

Secretaries.

JOHN EDWARD FORBES, F.G.S. | JOSEPH S. MARTIN.

Other Members of the Council

H. H. BOLTON.
R. D. DARBISHIRE, F.G.S.
RALPH FLETCHER, JUN.
G. C. GREENWELL, JUN.
CHARLES HARDWICK.
JOHN HIGSON.
W. H. JOHNSON, B.Sc.
GEORGE PEACE.
JOHN PLANT, F.G.S.
J. F. SEDDON.
A. W. WATERS, F.G.S.
GEORGE WILD.

Auditors.

JOHN HEELIS. | W. J. GRIMSHAW.

LIST OF MEMBERS.

NOVEMBER, 1876.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1874	*Agassiz, Alexandre,* Cambridge, Massachussetts, U.S.
1863	Aitken, John, F.G.S., Bacup. *Ex-President.*
1862	Alcock, Thomas, M.D., Oak Field, Ashton-on-Mersey.
1865	Ashworth, Edward, Stagg Hills, Waterfoot, near Manchester.
1864	Ashworth, John, Rose Hill, near Bolton.
1866	Bamford, J. B., Mining Engineer, Rochdale.
1875	Bangay, Dr., Cheadle, Cheshire.
1875	Barrett, W. S., 49, Old Hall Street, Liverpool.
1858	Bazley, Sir Thomas, Bart., M.P., Eyford Park, Stow-on-the-Wold, Gloucestershire.
1862	Beswicke, William, South Parade, Rochdale.
1838	Binney, E. W., F.R.S., F.G.S., 55, Peter Street, Manchester, *Ex-President.*
1867	Bolton, H. H., Newchurch, near Manchester.
1861	Brooks, Thomas, Sunnyside, Rawtenstall.
1859	Bryham, William, Rose Bridge Colliery, Wigan.
1862	*Buccleuch, His Grace the Duke of, Whitehall Gardens, London, S.W.
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1874	Byrom, W. A., F.G.S., 31, King Street, Wigan.
1874	Crofton, Rev. A., M.A., Reddish, Stockport.
1860	Crowther, Samuel, Bradford Offices, Bolton.
1859	*Coulthard, J. Ross, F.R.S.L., Croft House, Ashton-under-Lyne.
1862	Cross, John, 78, Cross Street, Manchester.

Year of Election.	
1861	Cross, John, Gidlow House, Wigan.
1868	Craig, William Young, Alsager, Stoke-on-Trent.
1876	Cunliffe, P. G., The Elms, Handforth, near Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., The Owens College, Manchester. *President.*
1862	*Derby, The Right Hon. the Earl of, Knowsley.
1860	Darbishire, R. D., B.A., F.G.S., 26, George Street, Manchester.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *Ex-President.*
1875	Diggle, A. A., Hindley Green Hall, Leigh.
1859	Diggle, James, Westleigh Colliery, Leigh.
1838	*Egerton, Sir Philip de Malpas Grey, Bart., M.P., F.R.S., Oulton Park, Tarporley. *Ex-President.*
1852	Egerton, The Hon. Algernon, M.P., Worsley Hall.
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1838	*Enniskillen, Earl of*, F.R.S., Florence Court, Fermanagh.
1860	Eskrigge, R. A., F.G.S., 18, Hackin's Hey, Liverpool.
1865	Evans, Walter, Middleton, near Manchester.
1863	Farrer, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1857	Forbes, John Edward, F.G.S., 5, York Street, Manchester. *Hon. Secretary.*
1873	Garforth, W. E., Lord's Field Colliery, Ashton-under-Lyne.
1874	*Geikie, Archibald*, LL.D., F.R.S., Ramsay Lodge, Edinburgh.
1858	Gerard, Lord, Bryn and Garswood, near Warrington.
1856	Gilroy, George, Ince Hall Colliery, Wigan.
1852	Greg, Robert Philips, F.G.S., Coles Park, Buntingford Herts.

Year of Election.	
1863	Greenwell, G. C., F.G.S., Poynton, near Stockport. *Ex-President.*
1874	Greenwell, G. C., junr., Poynton, near Stockport.
1865	Grimshaw, W. J., Stand, Whitefield, near Manchester.
1838	Hadfield, George, 24, Fountain Street, Manchester.
1866	Hall, John, Balderstone, Walmersley.
1864	Hall, Robert, Hope Foundry, Bury.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 72, Talbot Street, Moss Side, Manchester.
1874	*Hawkins, B. W.*, F.G.S., Century Club, East 15th Street, New York.
1874	*Hawkshaw, Sir John*, Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1860	Heelis, John, 37, Cross Street, Manchester.
1875	Hetherington, Joseph, 17, Dickinson Street, Manchester.
1874	Hewlett, W. H., Wigan Coal and Iron Co., Wigan.
1838	*Heywood, James, F.R.S., F.G.S., 26, Kensington Palace Gardens, London, W. *Ex-President.*
1862	Heywood, Oliver, Acresfield, Pendleton.
1876	Higson, John, 98, Albert Square, Manchester.
1874	*Hull, Professor Edward*, M.A., F.R.S., 14, Hulme Street, Dublin.
1875	Jackson, J., 5, Wood Street, Bolton.
1874	Johnson, J. H., F.G.S., Strangeways, Wigan.
1858	Johnson, Richard, 27, Dale Street, Manchester.
1870	Johnson, W. H., B.Sc., 27, Dale street, Manchester.
1844	*Joule, J.P., LL.D., F.R.S., Cliff Point, Higher Broughton.
1856	Knowles, Andrew, High Bank, Pendlebury. *Ex-President.*
1859	Knowles, John, Westwood, Pendlebury. *Ex-President.*
1864	Knowles, Kay, Swinton Old Hall, Pendlebury.
1858	Knowles, Thomas, M.P., Ince Old Hall, Wigan. *Ex-President.*

Year of Election.	
1858	Lancaster, John, F.G.S., Bilton Grange, Rugby.
1860	*Litler, H. William, Wallerscote, Leamington.
1862	Livesey, Clegg, Bredbury Colliery, near Stockport.
1838	Livesey, Thomas, Alton Grange, Ashby-de-la-Zouch.
1861	Lynde, J. G., F.G.S., City Hall, Manchester.
1873	Martin, Joseph S., H. M. Inspector of Mines, Park Villas, Prestwich. *Hon. Secretary.*
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1838	*Morton, Charles*, The Grange, Southport.
1874	*Morton, G. H.*, F.G.S., 21, West Derby Street, Liverpool.
1875	Nesbitt, George, 100, Burlington Street, Manchester.
1864	Nuttall, Thomas, Colliery Surveyor, Bury.
1874	*Ormerod, G. W.*, M.A., F.G.S., Brookbank, Teignmouth.
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester.
1874	*Owen, Professor Richard*, D.C.L., F.R.S., &c., British Museum, London, W.C.
1864	Park, James, Ironfounder, Bury.
1876	Peace, George, Beech House, Eccles.
1873	Pilkington, Edward, Clifton Collieries, near Manchester.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester.
1861	Pickup, Peter, F.G.S., Townley Colliery, Burnley.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford.
1867	Radcliffe, James, Lord's Field Colliery, Ashton-under-Lyne.
1866	Radcliffe, Richard, Preston New Road, Blackburn.
1874	*Ramsay, Professor, A. C.*, LL.D., F.R.S., &c., 15, Cromwell Crescent, South Kensington, S.W.
1860	Ridyard, John, Walkden, Worsley.
1873	Seddon, J. F., Great Harwood Collieries, Accrington.
1866	Selby, Atherton, M.E., Leigh.
1858	Shuttleworth, Sir James P. Kay, Bart., F.G.S., Gawthorpe Hall, Burnley. *Ex-President.*

Year of Election.	
1864	Smethurst, William, F.G.S., Garswood Hall Colliery, Ashton, near Wigan.
1838	Smith, G. Fereday, M.A., F.G.S., Grovehurst, Tunbridge Wells.
1873	Smith, Clifford, F.G.S., Parkfield, Swinton, near Manchester. *Ex-President.*
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall.
1844	*Sopwith, Thomas*, M.A., F.R.S., F.G.S., 103, Victoria Street, Westminster, S.W.
1862	Spence, Peter, F.C.S., Erlington House, Seymour Grove, Old Trafford.
1859	Statter, Thomas, Stand, Bury.
1876	Thompson, Joseph, F.G.S., Norley Collieries, Wigan.
1858	*Trafford, Sir Humphrey De, Bart., Trafford Park.
1873	Tonge, James, Hulton Colliery, near Bolton.
1862	Wadham, Edward, Millwood, Dalton-in-Furness
1862	*Walsh, Eli, Over Darwen.
1874	Waters, A. W., F.G.S., Woodbrook, Alderley Edge.
1865	Whipp, Thomas, Hawthorn Villas, Prestwich.
1867	Wild, George, Bardsley Colliery, Ashton-under-Lyne.
1859	Wild, John, Glodwick, Oldham.
1860	Wild, Samuel, Dean House, Buersill, Rochdale.
1838	*Wilson, Thomas*, Hillary Place, Leeds.
1874	*Woodhouse, J. T.*, F.G.S., M.I.C.E., Overseal, near Ashby-de-la-Zouch.
1876	Woodward, H. A., Clifton, near Manchester.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Honourable Francis, M.P.
1841-2-3	Heywood, James, F.R.S., F.G.S.
1843-4-5	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1849-50-1	Heywood, James, M.P., F.R.S.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1855-6-7	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1857-8-9	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart., F.G.S.
1861-2-3	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1865-6-7	Binney, E. W., F.R.S., F.G.S.
1867-8-9	Greenwell, G. C., F.G.S.
1869-70-1	Aitken, John, F.G.S.
1871-2-3	Knowles, John, M.I.C.E.
1873-4	Knowles, Thomas, M.P.
1874-5	Dawkins, Professor Boyd, F.R.S., F.G.S.
1875-6	Smith, Clifford, F.G.S.

ADDITIONS TO THE LIBRARY, 1875-6

TRANSACTIONS:—

1. London Geological Society.—"Quarterly Journal." Nos. 125 to 127, and Abstracts for the Session 1875-6. From the Society.
2. London Geologists' Association.—"Proceedings." Nos. 5, 6, 7, 8. Vol. 4. Annual Report, 1875. From the Council.
3. South Wales Institute of Engineers.—"Proceedings." Nos. 3, 4, 5. Vol. 9. From the Council.
4. Bristol Naturalists' Society.—"Proceedings." Part 1-3. Vol. 1. 1874-6. From the Society.
5. Literary and Philosophical Society of Manchester.—"Proceedings." Session 1874-5. From the Council.
6. Royal Geological Society of Ireland.—"Journal." Part 2. Vol. 4. 1874-5. From the Council.
7. Watford Natural History Society.—"Transactions." Parts 3, 4, 5. Vol. 1. From the Society.
8. Royal Institution of Cornwall.—"Journal." No. XVIII. 1876. From the Society.
9. Royal Dublin Society.—"Journal." No. 44. Vol. 7 1875. From the Society.
10. Royal Physical Society, Edinburgh.—"Proceedings." Session 1874-5. From the Council.
11. Natural History Society of Glasgow.—"Proceedings." Vol. 2. Part 2. 1876. From the Council.
12. Bulletin de la Société Vaudoise des Sciences Naturelles. Vol. 14. No. 75. 1876. From the Society.
13. Memoirs de la Société Geologique du Nord. Part 1. 1876. From the Society.
14. Atti della Societa Toscana. Vol. 1. Part 1, 2, 3. Vol. 2. Part 1. 1875-6. From the Society.
15. Sitzungs.—Berichte der naturwissenschaftlichen Gesellschaft "Isis" in Dresden. 3 Parts. 1875-6. From the Society.

16. Chester Society of National Science.—Annual Report for 1875-6. From the Society.
17. Dundee Free Library.—Reports for 1874-5. From the Committee.
18. Devon and Exeter Albert Memorial Museum and Library.—Report for 1875. From the Committee.
19. Leeds Naturalists' Club.—Reports for 1875-6. From the Committee.
20. Leicester Literary and Philosophical Society.—"Report for 1876." From the Council.
21. Leicester Town Museum.—"Report for 1876." From the Committee.
22. Manchester Field Naturalists Society.—"Report for 1875." From the Society.
23. North Staffordshire Naturalists Field Club.—"Report for 1876." From the Club.
24. Reports of the Sub-Wealden Exploration, from 1872 to 1876.
25. Catalogue of Books added to the Radcliffe Library, Oxford, in 1875.
26. Reports of the Inspectors of Mines for 1875. Presented by Joseph Dickinson, F.G.S.
27. The Coal Viewer and Engine Builder, by John Curr. 1797. Presented by W. J. Grimshaw.
28. Carboniferous Flora. Part 4. "Sigillaria and Stigmaria." By E. W. Binney, F.R.S., F.G.S. From the Author. (Palæontographical Society Publication.)
29. On the Relative Age of Post-Glacial Deposits in the North and South of England. By C. E. De Rance, F.G.S. From the Author.
30. Cause of the Glacial Period. By Dr. C. Ricketts, F.G.S. From the Author.
31. The Ice Age in Britain. By Ralph Richardson, F.R.S.E. From the Author.
32. Palæontology of the Carboniferous Strata, West of Scotland, with Vertical Sections. By Dr. Hunter. Parts 1 and 2. 1875. From the Author.

33. Royal Society of New South Wales.—Address by Rev. W. B. Clarke, M.A., F.G.S. From the Author.
34. Primæval World of Switzerland. By Professor Heer. Edited by James Heywood, F.R.S. 1876. From the Editor.
35. The Owens College Calendar, Session 1876-7. From Principal Greenwood, LL.D.

From the United States and Canada.

1. Smithsonian Institution, U.SA.—Annual Report for 1874.
2. Transactions of the American Institute of Mining Engineers. Vol. 3. 1874-5 Ryl. 8vo. pp. 464. From the Council.

Hayden, F. V.:—

3. Report of the United States Survey of the Territories. Vol. 2. 4to. 1875. "Vertebrata of the Cretaceous Formations of the West." By E. D. Cope.
4. Vol. 9. 4to. 1876. "Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri County." By F. B. Meek.
5. Vol. 10. 4to. 1876. "Monograph of the Geometrid Moths or Phalænidæ of the United States." By A. S. Pickard, junr., M.D.
6. United States Geological Survey of Montana and adjacent Territories. 1870-1. Two Vols. 8vo.
7. United States Geological Survey of Nebraska. Final Report. 1872. 8vo.
8. United States Geological and Geographical Survey of Colorado. 1873. 1876. 2 Vols. 8vo.
9. Bulletin of the United States Geological and Geographical Survey of the Territories. Nos. 1 to 6. Second Series. 1874-5.
10. Ditto. Vol. 2. Nos. 1, 2, 4. 1876.
11. Catalogue of Publications of the United States Geological Survey. 1874. pp. 20.
12. Catalogues of Photographs of the United States Geological Survey. 1874-5.

13. List of Elevations West of the Mississippi River. 1875. pp. 72.
14. Meteorological Observations in Colorado and Montana Territories. 1873-4. By G. B. Chittenden. pp. 57.

COLVIN, VERPLANCK :—

15. Topographical Survey of the Adirondack Wilderness of New York. Report for the Year 1873-4. 8vo.
16. First Annual Report of the State Parks of New York. 1874. pp. 22.

AGASSIZ, ALEXANDER :—

17. Annual Report of the Trustees of the Museum of Comparative Zoölogy at Harvard College. 1875.

CURRIER, DR. J. M. :—

18. Archives of Science, Orleans, County Vermont, U.S, Vol. 1. Nos. 8-9. 1874.

WINCHELL, N. H. :—

19. Geological and Natural History Survey of Minnesota. 3rd and 4th Annual Reports. 1875-6.
20. Vegetable Remains in Drift deposits in the North-West. 1875.
21. On the Parallelism of Devonian Outcrops in Michigan and Ohio. 1875.
22. Report of a Reconnaissance of the Black Hills of Dakota. made in the Summer of 1874. By Captain William Ludlow, U.S.A. 1875.
23. Report of Explorations in the Mineral Regions of Minnesota in 1848, 1859, and 1864. By Col. Charles Whittlesey. pp. 54. 1866.

SELWYN, A. R. C. :—

24. Report of Progress of the Geological Survey of Canada for 1874-5.
25. Catalogue of Canadian Minerals and Rocks in the Philadelphia International Exhibition. 1876. From the Geological Survey of Canada.

ADDITIONS BY PURCHASE.

Croll, James—Climate and Time. 1875.

Dana.—A System of Mineralogy. Fifth Edition. Re-written and enlarged, and illustrated with upwards of 600 woodcuts.

Appendix to ditto.

Second Appendix to ditto, by Geo. J. Brush.

Dana.—System of Mineralogy. Manual of Determinative Mineralogy, with an Introduction on BlowPipe Analysis. By George J. Brush. 2 Vols. 8vo. New York.

Geological Magazine. 1876.

Geological Record for 1874.

Tate and Blake.—The Yorkshire Lias. 8vo. 1876.

31 Geological Maps of the 6-inch Scale of the Lancashire Coal Field.

8 Vertical and Horozontal Sections in illustration of the above.

SOCIETIES WITH WHOM THE SOCIETY EXCHANGES ITS TRANSACTIONS, AND INSTITUTIONS AND JOURNALS TO WHOM A COPY IS SENT FREE.

I.—ENGLAND.

London	British Museum.
	Geological Survey.
	Geological Society.
	Geologists' Association.
	Royal Institution.
	Royal Society.
Manchester.....	The Owens College.
	Literary and Philosophical Society.
	Free Library, Camp Field.
	Scientific Students' Association.
	Salford Royal Museum and Library.
Liverpool	Geological Society.
	Free Library and Museum.
Leeds	Geological and Polytechnic Society.
	Free Library.
	Philosophical and Literary Society.

Leicester..... Literary and Philosophical Society.
Birmingham .... Free Library and Museum.
Cambridge ..... Geological Museum, University.
Oxford ..... Geological Museum, University.
Exeter ..... Albert Museum and Library.
Cornwall ..... Royal Geological Society, Penzance.
Royal Institution, Truro.
Truro..... Miners' Association of Cornwall and Devon.
Bristol ..... Naturalists' Society.
Warwick ..... Natural History Society.
Swansea..... South Wales Institute of Engineers.
Barnsley..... Midland Institute of Mining Engineers.
Dudley ..... Geological and Scientific Institute.
Newcastle-on-Tyne Institute of Mining Engineers.
Sheffield..... Free Library and Museum.
South Shields.... Public Free Library.
Watford..... Natural History Society.

II.—Scotland.

Edinburgh..... Geological Society.
Royal Society.
Royal Physical Society.
Glasgow..... Geological Society.
Natural History Society.
Dundee ..... Free Library and Museum.

III.—Ireland.

Dublin ..... Royal Dublin Society.
Royal Geological Society of Ireland.
Belfast ..... Natural History Society.

IV.—Foreign Societies.

Berlin ..... Geological Society of Germany.
Calcutta..... Geological Survey of India.
Christiania .... Royal University of Norway.
Dresden..... Natural History Society "Isis."

Lausanne (Suisse) Societie Vaudoise des Sciences Naturelles.
Lille ..... Société Géologique du Nord.
Paris ..... Societè Geologique.
St. Petersburgh .. Academy Imperial.
Turin ..... Academie Royale.

V.—Canada and United States.

Montreal ..... Geological Survey of Canada (A. R. C. Selwyn, F.G.S., Director).
McGill College (Principal J. W. Dawson, F.G.S.)
Albany, U.S..... Verplanck Colvin.
Boston, U.S..... Free Library.
H. D. Rogers, State Geologist.
Columbus, U.S.... Ohio, Geographical Survey of (Dr. J. S. Newberry, F.G.S.)
Easton, U.S..... American Institute of Mining Engineers.
Indiana, U.S. .. E. C. Cox.
New Haven, U.S. Professor O. C. Marsh, F.G.S.
Silliman's Journal.
St. Louis, U.S... G. C. Broadhead, State Geologist.
Washington, U.S. Dr. F. V. Hayden, U.S. Geologist.
Smithsonian Institution.

VI.—Australia.

Melbourne ..... Public Library of Victoria.
Sydney ..... Free Public Library.
Royal Society.
Newcastle ..... John Mackenzie, F.G.S.

VII.—Scientific Journals, &c.

Quarterly Journal of Science, Geological Magazine, Nature, Science Gossip, Mining Journal, Colliery Guardian.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VI. VOL. XIV. SESSION 1876-7.

At the ORDINARY MEETING of the members, held at the Rooms of the Literary and Philosophical Society, George Street, on Tuesday, 28th November, 1876.

Professor W. BOYD DAWKINS, M.A., F.R.S., President, in the Chair.

The List of Books added to the Library since last meeting was read; it included, among others, the following works:—

Memoirs, vol. v., 3rd series; Proceedings, vol. xv.; and Catalogue of Books in the Library of the Manchester Literary and Philosophical Society; Reports of the Leeds and Leicester Philosophical Societies; The Geology of England and Wales, by H. B. Woodward; Field Geology, by W. H. Penning; Coal, Iron, and Oil, by Daddow and Bannon.

INAUGURAL ADDRESS,

ON THE WATER SUPPLY IN THE RED ROCKS OF LANCASHIRE AND CHESHIRE.

BY PROFESSOR W. BOYD DAWKINS, M.A., F.R.S., F.G.S.

It is usually considered the duty of a President to begin the Session with an address, which should either relate to some special branch of enquiry, or be a record of the progress made by the science, which engages the attention

of the Society, during the past year. Of these two alternatives I have chosen the former, and the subject which, with considerable diffidence, I venture to discuss, relates to the important and difficult question of water supply, that is now rapidly becoming in this country one of the questions of the day. I propose to bring before you a few geological considerations relating to the Permian and Triassic Sandstones of this district, and to the quantity of water which they may be reasonably expected to yield.

I.—The Permian and Triassic Sandstones saturated with Water.

The experience of the last forty years in well-sinking in every part of Great Britain where the Permian and Triassic Sandstones occur, proves them to be saturated with water, and that they "are an admirable reservoir, capable of affording an almost unlimited supply of pure, though rather hard water." (Hull. Triassic and Permian Rocks of the Midland Counties, c. xii.) In support of this, it is necessary merely to quote the fact that, in 1863, six million gallons per day were obtained from these rocks in Manchester and Salford (Hull), a quantity that has since been largely increased by the sinking of new wells. The present weekly yield of the Triassic Rocks in the Liverpool district is estimated by Mr. Boult* at 128 million gallons. For evidence on this point, I would refer to the Report of the Committee of the British Association for Investigating the Underground Waters in the New Red Sandstone and Permian Formations, 1875, and to the Sixth Report of the Rivers Pollution Commissioners.†

* Journal, Liverpool Polytechnic Soc., April 24, 1876, p. 95. For further evidence, see the valuable tables appended.

† See also Papers by Messrs. Binney and Hull, Manch. Lit. and Phil. Soc. *passim*.

II.—The Water Level in the Rocks.

The water is stored up in these rocks according to their porosity, and in such quantity, that it has not yet been found necessary to sink wells much below mean tide mark in the area of Lancashire and Cheshire; the deepest well in Mr. Boult's tables being sunk 71 feet below the ordnance datum at Messrs. Macfie's Sugar Works, in Bachelor Street, Liverpool. The deepest boring is that of the Liverpool Corporation Works at Bootle, or 584 feet below the datum. The normal level of the water in the rocks is very various, and dependant in a great degree on the surface contours, that of the Runcorn Waterworks being the highest, or 250 feet, above the sea-level, according to Mr. Boult, in the district under consideration.

III.—Uncertain Supply in Permians.

The amount stored up in these rocks will obviously vary as their thickness. The Permian being deposited on an eroded surface of carboniferous strata, and being themselves uplifted and worn away by the action of the waves before the deposit of the Triassic Rocks, are of variable thickness. In this neighbourhood, the lower water-bearing sandstone, 250 feet thick at Collyhurst, is reduced to 12 feet 6 inches at the Seedley printworks, in the small space of two and-a-half miles. (Binney and Hull Brit. Assoc. Report 1875, p. 121.) Very frequently the Permian formation has altogether disappeared, and the Triassic rest directly on the carboniferous rocks. It is, therefore, to be looked upon as an uncertain source of water supply in this district.

IV.—Supply in Triassic Rocks.

The Triassic water-bearing rocks (exclusive of the impervious red marls) possess a gross thickness of from 1,700 to 1,900 feet, as may be seen from the following table :—

		A. Cheshire.	B. Liverpool and Preston.
		Feet.	Feet.
Keuper..	Red Marls.....	3000	—
	Waterstones	450-550....	400
Bunter..	Upper red and mottled Sandstone	500-600....	600
	Pebble beds	350-400....	800
	Lower red and mottled Sandstone	400	100

They consist of sandstones of various degrees of porosity, separated from each other by thin partings of impervious marl or clay, which divide the water into a series of sheets parallel to the dip of the strata. They are also traversed by faults which bring the various water-bearing strata into continuity, and render Professor Hull's view very probable that "the Bunter sandstone, in its three divisions, may be regarded in respect to water supply as a nearly homogeneous mass equally available throughout."

V.—Faults not Proved to be Watertight Barriers.

With regard to the faults themselves I am unable to meet with any evidence that they are, as suggested by Mr. Stephenson, filled with clay so as to form watertight compartments. But, on the other hand, in the case of the well at Flaybrick Hill, near Birkenhead, and in that at Whiston, belonging to the St. Helens Corporation, the amount of water obtained by penetrating to a fault was largely increased. Some of them may be open fissures which would act as natural conduits as Professor Hull has suggested in explanation of the large quantity of water produced by the Green Lane Well at Liverpool; but they may be expected more generally to be filled with the results of the friction of one side against the other, and with various materials

A. Hull. B. De Rance, Report of British Association, 1875.

deposited by water which has at some time or another flowed through them. According to Professor Hull, they offer favourable sites for wells. As the evidence stands, I have no proof of the presence of any fault in these porous water-bearing strata which is puddled and watertight.

VI.—No Proof that the supply grows less at great depth.

Nor am I able to meet with satisfactory proof that the amount of water in these rocks diminishes with the depth. In the case of the Green Lane Well above quoted, which has been urged in support of this conclusion, the lessened increase, as the bore-hole went down, may reasonably be accounted for, either, by the bore-hole passing away from a water-bearing fault which it had intersected above, or by the greater compactness of the lower sandstones traversed in its lower course. The general experience of well-sinking in the porous sandstones of the Trias, not merely in this neighbourhood but everywhere else, proves that, as a rule, the deeper the sinking the greater is the yield of water, and may fairly be taken to show that the deepest portions of the porous rocks are also water-bearing. And it must be remembered that if they are rendered more compact at great depth by the pressure of the superincumbent rocks, that pressure would also cause the water to traverse them more easily than it would do at the surface. On this point I would refer to the experiments of Mr. Isaac Roberts, which show the effect of pressure in accelerating the passage of water through sandstone rock.*

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* He found that the passage of water per hour through a block of sandstone 10½ inches thick was :—

Under pressure of	10 lbs.	to square inch	.. ..	4·5 gallons.
„ „	20 lbs.	„	.. ..	7·5 „
„ „	46 lbs.	„	.. ..	19·0 „

Liverpool Geological Society, 1868-69.

It is well known that water can be forced through the pores of steel under enormous pressure. The reason why there are no deep wells in these rocks in Lancashire and Cheshire, is simply that hitherto an ample supply has been furnished by superficial wells, and not on account of the failure of water at great depths.

The evidence seems to me to be conclusive that these rocks, which are so abundantly charged with water at and near the surface, are also abundantly charged with water even when sunk to a depth of thousands of feet. That porous strata do contain water in vast volume at depths of more than 1000 feet, is shown by an appeal to Artesian Wells in France, and to the Warren Farm Well, near Brighton, which is the deepest as yet dug in the country, or 1285 feet.

VII.—Hydrographical Relations of these Rocks in Lancashire and Cheshire.

We will now consider the range of these rocks in the area under consideration. A glance at the maps of the Geological Survey will show that they rest in a great hydrographic basin, bounded on every side, except the sea, by the older rocks. Starting from Manchester southwards, past Macclesfield, as far as Shrewsbury, the boundary is composed of Permians and Carboniferous and the anteclinal, passing from the latter place to Tunstall. Thence it is marked by the Coal-measures and Permians of Oswestry and Wrexham, and the estuary of the Dee. From Manchester it runs to the west as far as Croxteth Park, and then turns sharp to the north, being composed of Coal-measures nearly up to Preston, and, thence to Fleetwood, being formed of lower Carboniferous Strata and Permians. In this hydrographic basin, hollowed in the Palæozoic rocks, are three depressions—1. That of Fleetwood, Southport, and Orms-

kirk, in which the water in the Triassic Strata can gravitate seaward with the greatest freedom, and which demand no further notice in this place; 2. That which has for its centre Upton-in-Wirral; 3. That which is marked by the Liassic outlier of Ash Magna to the east of Whitchurch. The water-bearing strata in these two last are connected together by the sweep of sandstone between Chester and Huyton, and occupy an area which is about 800 square miles, as measured in the Geological Survey maps. In the greater of these depressions, which occupy the plains of Lancashire, Cheshire, and Shropshire, the water-bearing Triassic rocks are sunk 4200 feet below the ordnance datum near Ightfield, and 400 feet near Nantwich; in the smaller, or that of Wirral, to a depth of 2400 feet. If reference be made to the careful sections reduced from those of the Geological Survey and prepared by the Director-General for the Coal Commission (Sixth Report, Nos. 16, 19, 26), it will be seen that these two depressions form part of a great trough, from which the surplus water can only escape through the narrow space between the estuary of the Dee and Croxteth Park, shown in Section 26 of the report.

VIII.—The Two Depressions connected.

In the broad anticlinal by which they are separated, the normal water-level varies from 50 feet at Ince, to 13 at Hale, and 10 at Garston (Boult), above datum; and since these wells are in the pebble beds, it would follow that the barrier of Carboniferous Rocks below is sunk at least to a depth corresponding with, say, one half of the total thickness of the pebble beds plus that of the lower sandstone, or to about 600 feet. In this, then, we have ample proof that the depressions are connected, and that there is no barrier between them which would prevent the circulation of water. The deeper of them may be viewed as a vast subterranean reservoir, the overflow from which gravitates seawards through the

shallower, the permanent level of the water in the rocks forming, on the whole, an inclined plane, rising from the sea level at least to the height of 250 feet above it, as proved at Runcorn (Boult), and broken by the rivers and their tributaries. It seems, therefore, obvious that in this area we have a vast supply of water far below any of the wells which is at present untouched, and which is kept up by the rainfall, and percolation from rivers.

IX.—The Amount of Percolation.

The enquiry into rainfall and evaporation by Messrs. Symonds, Greaves, and Evans, recently published in the Proceedings of the Institute of Civil Engineers (Vol. 45, Part iii., 1876, p. 29), gives us data by which we can calculate the amount of rain taken up by porous strata. The average percolation is not over-estimated at about one-third of the rainfall; but in the case of sand, according to Mr. Greaves' experiments, it amounts to no less than 83 per cent. It is estimated in this district, by Professor Hull, at one-third; but occasionally, according to him, it may rise as high as one-half, or even two-thirds. There are, however, certain facts which must be taken into account in any calculation, and which may disturb the accuracy of the results. On the one hand, we find that about 300 out of the 800 square miles are covered with impervious Keuper Marls, and the outcrop of the water-bearing strata is frequently masked by boulder clay. On the other hand the outcrop is frequently covered by the loose sand and shingle of the drift, which take up more than one-third of rainfall. It must also be remembered that the water thrown off from the Keuper Marls has to pass over the porous Triassic sandstones, and that the whole of the water from the sheds of the Dee and Mersey has to run the same chance of being in part absorbed in its passage. That this chance is by no means

small, is proved by the vast quantities of water lost by the tributaries of the Thames in their passage over permeable strata. (Evidence of Mr. John Bravender; Sixth Report of Rivers Pollution Commission, p. 298.) The deep wells of Manchester and Salford are believed by Mr. Hull to be replenished by the waters of the Irwell, Irk, and Medlock, which are filtered by the process.* Taking all these parts into consideration, it seems to me that one-third of the average rainfall over the whole area of 800 square miles is a minimum estimate of the amount of percolation which would take place were the rocks not saturated. This would result, if the rainfall be taken at 30 inches, in a quantity of no less than 114,688 millions of gallons which may be drawn upon annually, irrespective of the amount stored up. In the presence of these figures there is little fear of the exhaustion of the water in these rocks, at all events for some time to come. At present they are saturated, and the surplus water which they cannot take up flows over the surface. If large quantities of water were abstracted from them, the vacuum would rapidly be filled up by increased percolation.

X.—Quality of Water.

The water in the Red Sandstone is, as a rule, good though hard. (Binney.) At Ordsal, however, at a depth of 460 feet in the Lower Bunter it was so salt that the boring had to be given up. It was also found to be salt at a depth of 670 feet at Dallam Forge, Warrington (Boult), probably in the "Pebble beds," and it is highly charged with gypsum at Appleton, in Cheshire.

XI.—Advantages of a Deep Well with a Diaphragm.

The mode of getting at this store of water which recommends itself to me, is to sink a deep shaft or boring below the

* The experiments of of Dr. Angus Smith (see Brit. Assoc. Reports, 1848), prove what an admirable filter these sandstone rocks are.

ordnance datum line some 800 or 1000 feet, so as to tap the various strata which are, as a rule, not very much out of the horizontal, to shut off all communication in the shaft or boring between the superficial water and that in the lower part, and to supply the pumps from the bottom water. In this way sewage-contamination would be rendered impossible, and a far larger area would be laid under contribution for the immediate supply of the vaccum at the bottom then would be contributed to the restoration of the surface water under the ordinary system of pumping. If, indeed, the diaphragm happened to be at the point where a layer of impervious marl was traversed in the well, it might be possible to obtain large quantities of water from the lower rocks without seriously affecting the surface levels immediately above. In any case, the pressure of the water at great depths would be an enormous advantage, since it would cause the vacuum produced by the deep pumps to be filled up more quickly than at levels near the surface.

The important question as to the area of rock contributing its water to a well of a given depth seems to me to be asked in vain in the present state of our ignorance. It may, however, be observed that in Liverpool the stoppage of the Dudlow Lane pumps raises the level of the water at Oakfield Quarry, 2¼ miles away, although they merely dip into the surface of the subterranean roservoir.

Water in a depression filled with sandstone may be expected to behave as water in a lake in which a vacuum in any part is filled up at the expense of the general level. The rapidity, however, with which this will be brought about will be retarded by the friction of the particles of water in traversing the rock, which will vary according to its porosity. In deep wells the enormous pressure of the water at the bottom causes the vacuum to be filled up with great swiftness.

XII.—Conclusion.

The general conclusion which I venture to draw for myself, at least from the above considerations are; 1st, That in the Triassic area of Lancashire and Cheshire there is a vast subterranean lake fed by subaerial water; 2ndly, That the most advantageous mode of getting at it is by sinking deep wells; and lastly, That the vacuum caused by pumping at great depths in the manner suggested would be more rapidly supplied by percolation from the surface of rain and river water, than near the surface. The subject is of equal interest to the geologist and engineer, and one of very great importance to the public. I have only to regret the very imperfect manner in which I am able to lay it before the Society.

A vote of thanks to the President was unanimously carried.

Professor Boyd Dawkins, in acknowledging the vote of thanks, said: I should like to say that this question of the water supply is a question of very great interest and importance, and it is one on which no two persons can be expected to have precisely the same ideas. I think it would be a great benefit, if at any future meeting of the Society we could get the advantage of any gentleman's views—on any of the points which have been discussed. The question is one of especial interest in this part of the country, and I am sure we shall be very glad, as a Society, to get information from any quarter from which it is obtainable.

THE SOUTH-LANCASHIRE AND BURNLEY COAL FIELDS.

Mr. C. E. de Rance, F.G.S., of the Geological Survey, exhibited and described a new vertical section of the South Lancashire and Burnley Coal Fields.

A NEW DESCRIPTION OF BRATTICE CLOTH.

Mr. W. H. Johnson exhibited some samples of a new description of brattice cloth, which, instead of being composed of the ordinary material, has wire for the basis. The wire cloth is woven with some 36 holes to the inch, the wire being extremely fine—in fact, almost as fine as iron wire can practically be drawn—and it was claimed for the manufactured article that, if used upon any larger scale in mines, it would possess the following advantages:—It would be found much more durable than the ordinary bratticing, and at the same time possess greater strength. Its greatest recommendation lies in its power to resist heat. A piece of the new cloth was exposed to the flame of a Bunsen burner, with the following results:—The under surface was at first only charred, and it took some little time before the charred matter was burnt away so as to allow the flame to go through. When exposed to a flame of somewhat less strength, the under surface was merely charred, and the fabric was not penetrated by the flame. (Samples exposed to heat of varying intensity were exhibited.) The fabric, moreover, was practically waterproof.—A vote of thanks to Messrs. De Rance and Johnson was unanimously passed, and the meeting terminated.

TRANSACTIONS

Five sections to illustrate Mr. Grimshaw's paper will be issued with Part viii.

[illegible], 1878,

JOSEPH DICKINSON, F.G.S., Vice-President, in the Chair.

Mr. R. J. Barnes, Chowbent; Mr. W. H. Chadwick, Little Hulton; Mr. Alfred Moore, C.E., 5, Clarence Street, Manchester; Mr. J. H. Penman, Booth Street, Manchester; Mr. R. Winstanley, Lancaster Avenue, Manchester; Mr. W. Topping, Ashton, near Wigan; and Mr. J. Unsworth, Wigan, were elected members of the Society.

ON THE ROCKS OF THE BALLYMONEY SERIES, Co. WEXFORD.

BY G. H. KINAHAN, M.R.I.A., &c.

The rocks, to which it is intended to draw attention, belong to the Cambro-Silurian formation. They may be interesting to the members of a commercial city like Manchester, as it is possible, if not probable, that at some time or another they will be turned to profitable account

in respect to the iron ores they contain. Although they seem to extend across the County Wexford they are best seen on the coast section, between Courtown and Arklow, in the neighbourhood of the Ballymoney fishery, after which place it is proposed to call them. Previous to giving a special description of the rocks, the subject of this communication, it may be interesting to give an epitome of the geology of the County Wexford.

The geology of the County Wexford is very obscure for various reasons—*First*, the the country is obscured with drift and other more recent accumulations, which prevent the ancient formations from being seen, except in small detached exposures. *Secondly*, the ancient and recent rocks have been severely broken up and displaced by faults or dislocations of different ages, ranging from the remotest period of which we have record to very recent times—and, *Thirdly*, all the rocks are generally more or less metamorphosed. Sometimes this action extending over large tracts, which may be called metapepsis (regional metamorphism) while in other places it is local or Paroptesis (local metamorphism). The subject of metamorphism, however, is foreign to the present paper, it is, therefore, sufficient to draw attention to the different kinds.*

The oldest rocks in the County Wexford are of Cambrian age. These have been worked by Griffith, De la Beche, Warrington Smyth, Jukes, Wyley, Du Noyer, and others, who have found their relations to the overlying Cambro-Silurian rocks to be very irregular and obscure, as in three or four places only are junctions exposed. In one of these, a massive "slate conglomerate," lies on "Submetamorphic" Cambrian rocks, while in the rest there are more or less complicated fault boundaries.

* The different kinds of metamorphism and their causes were treated of by the writer in a paper read before the Edinburgh Geological Society during ast Session—1875-6—to which those interested in the subject are referred.

It has also been found very difficult to separate the Cambrian from the Cambro-Silurian, because in places the rocks are nearly identical, the most marked distinction in this area, lithologically, being that black carbonaceous rocks are more or less characteristic of the latter while they rarely, if ever, occur in the former. Within the last year, Mr. E. Leeson, Fossil Collector of the Government Survey, has discovered fossil evidence in various places in this county whereby the area of the Cambrian rocks can be more definitely fixed.

The Cambrian rocks were dislocated, broken up, and more or less metamorphosed, prior to the dawn of the Cambro-Silurian period, the latter having been deposited on them unconformably, but, as these will be mentioned hereafter, it is at present only necessary to remark, that they also subsequently were extensively disturbed by faults, and tracts of them affected by metamorphism both metapepsis and paroptesis.

Of the Silurians proper (or Upper Silurian rocks) there has been no trace discovered in this county, but on the older rocks, in a few places, there are greater or less tracts of Carboniferous rocks. These are also much displaced by faults, while over all, are deep drifts of various ages and more recent accumulations. All these latter groups, from the Carboniferous upward, are extremely interesting, but further notice of them would be out of place here.

Cambro-Silurian Rocks.

These rocks, as previously pointed out, are in general more or less metamorphosed, but in places we can learn their general characters. Below, from the fossils, they are evidently of Caradoc and Llandeilo ages, while above are the rocks of the Ballymoney series. The lower divisions in general consist of—

3. Green and greyish grits, shales, and slabs.
2. Flaggy grey and green grits, and shales.
1. Black, blackish, and grey grits, shales, and slates; the black beds predominating.

In one place in the county a "slate conglomerate" occurs at the base of No. 1. But the section usually is somewhat similar to the above; still, it is quite evident that the position of the rocks is solely due to local circumstances; as in some places the arenous beds are below the argillous, and in other places they are reversed; showing that the arenous (in which Caradoc fossils occur) are shore beds; while the others were deposited in still, deep water. The flow tide currents of the Cambro-Silurian sea would seem to have come from the southward, as on the south shores of the Cambrian islands and land, sand and coarse materials were deposited; while to the north of the islands, or in shelter of the land, the accumulations were more or less fine and argillous. Slight changes in the direction of the currents changed the nature of the sea, and consequently the conditions of life, so that the fossils of Caradoc and Llandeilo ages are found in places in alternating beds.

The upper group of the Cambro-Silurian rock, or the Rocks of the Ballymoney Series, are most interesting and peculiar. Evidently they are above those just described, but in no place has a section yet been seen that satisfactorily shows the relations between the two groups, on account of the numerous faults and of the envelope of drift, or other superficial accumulations. From what has been stated, it is evident that during the early portion of the Cambro-Silurian period in this area, there was a more or less tranquil sea, but it seems to have been getting shallow by degrees; after this, however, there seems to have been a complete change, as the area was affected by vulcanicity, in different phases. One,—out of fissures, masses of molten matter was poured,

that might, or might not, be associated with irruptions of tuff and such like mechanical accompaniment; a second,—in places there were springs ejecting solutions of lime, silica,* iron, and such like.

A general selection of the Cambro-Silurian rocks, as seen on the Ballymoney and Courtown coast is as follows:—

1. Outlyer of Cambrian rocks a little south of Pollshone harbour.

2. Fault.

Caradoc and Llandeilo Rocks.

3. Blackish and greyish talcose argillytes much shifted and disturbed by small faults, these rocks all dip southward towards the Cambrian rocks at high angles (65 to 80); they occur along the coast for more than half a mile, to Glenbeg Head.

4. Over a mile of Æolian drift (blown sand) that obliterates the section.

5. For half a mile south of Courtown harbour there are greenish, greyish, and bluish thin grits, shales, and slates much broken up and twisted by faults; some of the shales are impregnated in numerous cracks and along the bedding lines by thin films of limonite. The general dip of these rocks is southward, but they are nearly perpendicular.

Bellamoney Series.

6. For half a mile north of Courtown harbour, in the cutting for the canal, the rocks in general are greenish shales and slates. Some beds, however, are purple. These dip both north and south, at high angles (65 to 85).

* The silicious springs probably marked the dawn of the vulcanicity, as the Quartz-rocks found in the lower group of the Cambro-Silurian rocks are evidently due to some such cause.

DRIFT, PEAT, &c., OF HEYSMAN, MORECAMBE BAY.

By Rev. Addison Crofton, M.A.

The coast of Morecambe Bay from Hest Bank to Heysham has been visited and examined by me every summer for the last ten years, and, though possibly many of the facts I have noticed are mentioned in former papers of this or kindred societies, yet I venture to lay before the meeting the results of my investigation.

Proceeding along the coast from the Railway Station at Hest Bank, we find only low-lying drift deposits of no special interest until we reach the promontory of the village of Bare, here the shore begins to be more interesting; and, in addition to the fine specimens of mya arenaria and truncata which may here be found, we come across a well-exposed deposit of peat, resting on a blue stiff marl, between high and low water mark, and close to the former. At this point the shingle has been shifted so as to expose the peat, but, in all probability, the deposit lies under the pebbly shore for some distance on either side, and the blue clay, emitting a rank and noisome smell, may be seen a few score of yards further on, just where the great bank of shingle runs out from the shore and forms the natural breakwater, behind which are sheltered the worn-out or disabled boats of the Poulton Ring fishermen.

In Morecambe, which we next reach, the drift deposits show many large and interesting boulders, many of which, of great size, have been dug up in making roads or laying foundations in the new part of the village.

Passing through Morecambe, and taking to the shore again below the North-Western Hotel, we find, near low water-mark, about midway between the stone pier and the fishing baulks, another deposit of marl and peat which has

been covered by the sand, and again exposed by an alteration in the channel and the direction of currents.

On this lies, in many places, a considerable layer of small shingle covered with thousands of oyster shells, mixed with many shells of pecten opercularis, all empty, old and stained black, and held together by colonies of living mussels. This has evidently been an oyster ground at some distant date when ostrea edulis was not the rarity that it now is. Beyond this are the vast beds of shingle and boulders occupied by the baulks of the fishermen.

Opposite these baulks, and above the high-tide mark, rises the drift mound locally known as the Cross Stones, the greater part of which has been washed away by the sea, and on which small encroachments are made every winter. The deposits here are chiefly sandy or gravelly clays interspersed with boulders of various sizes.

These boulders are continually being dislodged from the cliff, and many hundreds of all sizes lie along the shore and extend outwards to the fishing baulks, marking with some degree of accuracy the position and extent of the original mound. The reefs on which the baulks stand are, probably, themselves a remnant of the same deposit.

The Cross Stones drifts contain a few species of shells which are found in some abundance near the top of the cliff, lying about two feet deep, on an average, below the surface, and in a bed of six inches to a foot thick. I have found there—

1. Mytilus edulis, abundant but imperfect and much decomposed.
2. Cardium edule, common, but less so than the preceding species and less injured.
3. Ostrea edulis, a few specimens.
4. Littorina littoralis, very little worn or altered, except in colour.
5. Buccinum undatum, broken.

6. Purpura lapillus, perfect.

Several of the boulders have well-defined ice-marks parallel to their greater axis. I have one, about a pound in weight, consisting of encrinital black limestone, which is deeply furrowed in parallel and clearly-cut grooves. The boulders have been brought apparently from the opposite shore of the bay, the slates and limestones being identical with those of the Lake district, and the granites resembling those of Eskdale and the neighbourhood.

Beyond the Cross Stones Hill the cliffs gradually become lower, until, on reaching the old lime-kiln, we find the path close to the high-water mark. Here stands a solitary house, built just where a peat deposit comes out on the shore with a few trunks of birch-trees here and there, exposed by the action of the sea.

Past this rises another hill of red-drift, like the Cross Stones, and containing the same shells under similar circumstances, and on the further side of this hill begins the quaint little village of Heysham on the new red sandstone.

The peat moss, noticed above, formerly extended much further out to sea, and has been gradually worn away by successive encroachments of the sea; the contents of this moss have either been swept by the tide out into the Irish sea, or have been arrested by the fishing-baulks of Heysham. Along the shore may often be noticed water-worn pieces of bog-wood and rounded lumps of hard peat, and in the baulks, down by low-water mark, the horns of the red deer are met with not unfrequently.

In the Museum at Morecambe are two specimens from this locality; the postman in the same village has another, a fine left antler; and I have in my own collection a left horn with portions of the frontal bone attached, which was found there in 1872. My specimen has eight points, and is 3ft. 7½in. from base to tip.

ON THE METHOD OF WORKING "REARING" MINES AT LEYCETT, STAFFORDSHIRE.

By Mr. W. J. Grimshaw.

The writer has thought that some sketches of contorted strata at Leycett, in North Staffordshire, and some notes on the method adopted in working the steep mines there found would not be without interest to the members of this society.

Every mining district has its customs; customs born of experience, which will, in the main, be found suited to the requirements of the case. Customs may be modified with advantage betimes, but there will generally be found some ruling principle which influences in great measure the amount of change which may be safely made, and the mode in which it may be effected.

Any mine which dips at an angle of between 30 and 90 degrees is termed a "rearing" mine. It does not often happen that the "rearers" exclusively continue for any great distance; the alternations of dip producing tracts of mine which are locally termed "flats," and in which the dip is much more moderate.

The Leycett Collieries are situate about four miles to the west of Newcastle-under-Lyme, and about two miles to the south of Audley. They are on the west side of the great North Staffordshire Fault, which runs through Talk-o'th'-Hill, Bignall Hill, Apedale, and White Barn.

Somewhat to the north of Bignall Hill a "saddle" commences which runs by Apedale Hall, Alsager's Bank, and Scot Hey, from thence inclining in a south-westerly direction towards Leycett. On the east side of this "saddle" the dip is generally comparatively slight, but on the west it is very variable, and in some places extremely steep.

The workings of the Leycett Collieries are exclusively on the western side of this "saddle," the general dip being towards the west, or what is known as the "Cheshire dip."

The mines worked at Leycett have in nearly all instances very friable roofs, consisting of alternations of metal and bass. The metal is mostly of a "shelly" nature. The highest mine at present in working is the Single Four Feet. This mine is 5ft. 6in. thick, the roof is tender bass, about 3½ft. thick, and the floor is hard warrant. The Single Five Feet Mine lies about 20 yards below the Four Feet; the thickness is 4ft. 6in., the roof is extremely tender, and falls for a great height. The floor consists of 4in. warrant, lying on 13 yds. of rock, and heaves very much. The quality of the coal is best house-fire. At a depth of about 40 yards below the Five Feet we come to the Ragman, Seven Feet, and Hams Mines, the section of which is as follows:—

Roof—Smooth Bass.

	Ft. in.	Ft. in.
Ragman Coal	4·0	
Strong Bass	..	6·0
Seven Feet Coal	7·0	
Yardley Inferior Coal with pyrites	..	0·10
Holing Dirt	..	1·3
Hams or Rough Five Feet Coal	5·6	..
Total Coal	16·6	Dirt 8·1

The floor is fireclay, 4in. to 6in. thick, resting on strata of a rocky nature. In working these mines simultaneously the levels are driven in the Hams or Rough Five Feet Coal, the holing dirt and Yardley being taken down, thus leaving the bottom of the Seven Feet Coal for a roof. In "drifting-back" the Seven Feet is easily gotten, but a considerable quantity of the Ragman Coal is lost by being buried in the

"gob." In this working, gob fires are of frequent occurrence.

Some distance below the Hams coal the Ten Feet Mine is found 7ft. 6in. thick; the roof is bind, and the floor fireclay, between 8ft. and 9ft. thick. The Two Row Coals, lying below the Ten Feet Mine, are not worked at present, and the Seven Feet Banbury coal, 5ft. 6in. thick, is in course of opening out. The distances between the mines are somewhat variable.

Where the dip of the mines is very steep, the area of coal which can be opened out at one operation is much curtailed in comparison with that which may be opened out in a seam of ordinary inclination. It is practically impossible to open out any dip workings, on account of the difficulty and expense of haulage and pumping operations. In the case of "rearing" mines it is better to confine operations to the works which may be opened out of the "shaft" or "shaft-tunnel" levels, and to open out new ranks by sinking the shafts deeper and tunnelling out afresh, as may be deemed advisable. The first operation in opening out a rank of coal in a "rearing" mine is to drive out a pair of levels from 6 to 7ft. wide, about 12 yards apart, with small "cut-throughs" or "jack holes" every 18 or 20 yards. These levels are continued till they reach within 100 yards of a boundary, fault, or other line from which "drifting" or "getting back" may be safely started. Such a point having been reached [*See Sketch* 1.], a brow of about 3 yards in width is driven directly to the rise of the mine, levels being started out of it every 10 or 12 yards, measured in the line of dip. Each of these levels eventually becomes a drawing road to [*Sketch* 2.] the brow, which is fitted up as a balance-brow, with a carriage into which the tubs are run and let down to the main level. The empty tubs are returned on the carriage, and a simple arrangement allows the full tubs

to push the empties off the carriage, as is now generally done in "caging" at the shaft. A balance-brow of 100 yards in length, and dipping from 30 to 60 degrees, will, if in good working order, land 300 tubs per working day of 10 hours. In some cases slant-brows are driven, the course often being at an angle of 20 to 25 degrees from the level course. These slants are more difficult to keep in order than brows driven on the direct rise and dip course. They are, however, almost indispensable when the coal from various districts requires conveying to the shaft level, as several balance-brows would in many cases be required in place of one jig-brow.

In some cases the coal gotten in the several levels or drifts is tipped into the "cut-throughs" or brows, spouts or screens being fixed at the bottom, from which the coal is emptied into pit tubs standing in the drawing road. These "cut-throughs" require keeping full, or else the coal is very much broken. The last-mentioned means of conveyance is the only reasonably practicable method of dealing with the matter in cases where the dip of the mine exceeds 60 degrees.

In driving "strait-work" in these "rearing" mines, falls of roof need to be guarded against as carefully as may be, for if the roof begins to slip off the top of the coal on the high side pillar, it is almost impossible to stop it. In addition to this, there is practically no stowage room in the pit, and all falls would require to be sent to bank. It is found best to leave at least one foot of coal on the roof of every level, and where possible, a still greater thickness. The writer has seen instances where the "guttering" of the roof has extended from the level to the air end, 12 yards above.

Where the floor is exposed, as in sketch 2, the coal often requires to be carefully spragged at the foot on the high side. In case the mines are thin, it is no doubt impossible to

make roads without laying bare the roof, and possibly taking a portion of it down, or else taking the floor up. This may answer fairly when the roof is good, but in case of an indifferent roof, a small thickness of coal left against it will, in the majority of instances save trouble and expense.

The mine being opened out in pillars of about 18 by 12 yards for 100 yards square from the boundary, drifting back is first commenced in the high level, and by the time it has advanced about 10 yards, the roof has probably fallen. Drifting is then started in the level below; the fallen roof, &c., in the drift above being supported by the pillar which is being gotten. As the lower drift approaches the top of the pillar, the weight above generally makes itself evident by the "gulching" and cracking of the coal. The drift is then widened at the top end as much as possible, and the small pillar of coal against which the gob is resting is thinned as much as can be safely done. A shot is then planted in this pillar and fired; the result generally being what is locally termed the "shooting of the gob." When, as sometimes happens, the shot does not produce the desired effect, the place may be on the move for days, and occasionally weeks, before the gob shoots. When once the gob begins to drop, it is certainly unsafe to venture up the drift, as there is no chance of escape therefrom in case of either a small or large fall occurring. The drifts should not follow too closely. The rise drift should be, at least, 10 yards in advance of the drift below it, and so on throughout the series. It sometimes happens, when the drifts follow too closely, that the shooting of one gob causes that of several others, which is extremely dangerous to those working in the lower drifts. Such an occurrence often causes considerable alarm in the pit, as the air is reversed, the doors blown open, and sometimes down.

It occasionally happens, when drifting against old works,

that the coal may be cleared without the gob shooting. In such case the practice is to insert ¼lb. of dynamite into a crevice in the gob, the firing of this generally causes the desired slip.

In drifting, the coal is mostly gotten by blasting, the the pick being comparatively but little used.

In a mine dipping at the rate of 30 degrees, practice shows that the drifts would be brought back at an angle of about 70 degrees off the level course. If the inclination exceeds 45 degrees this angle would not exceed 40 degrees. The method of getting the coal varies considerably in the different mines, but the operation may be broadly summarised thus:—The drifters commence at the bottom end of the drift, just above the drawing level, and plant their shot or shots so as to blow the coal parallel to the line of the drift; then mounting on the gob, other shots are placed to blow the coal down to the loose end left after the first shot. The charges of powder used vary from ¾lb. to 1¼lb. per shot, and the quantity of coal blown down varies from 5 to 15 loads, or 2 to 6 tons per shot.

A considerable quantity of timber is sometimes required to keep the drawing roads good for about a chain in advance of the drifts; but in the drifts themselves it is impracticable to set much.

The "rearing" mines have generally been worked from the outcrop in successively deeper ranks. This causes a rapid drainage of the gas, and is also often the cause of a liberal supply of water, which is certainly the lesser evil of the two in such mines.

In opening out, especially if the coal is dry, the gas is generally very strong, and shows little sign of abatement till some communication is made with the old works of the rank above. When such communication is effected, water generally slowly makes an appearance, and where the water

finds a way in, the gas finds a way out, as will be evident in course of time by the lessened quantity requiring to be dealt with.

The writer is not aware of any instance in which a considerable body of water has been tapped in a "rearing" mine, but is inclined to think that the probability or otherwise of such an occurrence must greatly depend on the manner in which the coal was gotten in the old workings. If it was gotten clean, but little standage room would be left, on account of the gob loosely filling up the space, and the water causing it to swell. If the old works consisted partially of strait-work, with a fair roof, water might collect to some extent; but water, bad as its effects are on the roof and floor of a mine of ordinary inclination, works even more havoc in a "rearing" mine. As may be imagined, the gas is strongest in the cut-throughs or "jack-holes," which are driven just large enough for a man to work in, and as rapidly as possible, being enlarged, if needed, when a holing has been made into the level above. Brattice is seldom used. Sheet-iron air pipes, about 10 inches diameter, are chiefly used, and it would be difficult to ventilate rise places by most other means. Possibly half-inch boards might be used, but the jack-holes would require to be driven larger to allow of their use. The chief objection to iron pipes is that they throttle the air, but the writer is not able to mention a substitute which would possess the same advantages. There is this advantage in their use, that two sets of pipes, or even more, may be used to ventilate the places, if found needful. When the pipes have been used for "blowing" air, the writer has had lengths made with the mouth "belled out" to about two feet, and has found that the current of air has been somewhat increased by that addition. In "drifting," naked lights are almost indispensable, to guard against the frequent falls of coal. These falls

are generally small; but a small piece of coal or metal falling from the top end of the drift may cause a serious accident.

Generally speaking, but little if any gas is to be found in the goaf, if the works in operation have any communication with the old workings. Gas may occasionally be found in the top drifts, but it seldom happens that the gob shoots so closely as to make up the airway round the face of the drift; and, in addition, the gob acts as packing, preventing the sudden fall of any large quantity of roof. Gas is seen in the goaf sometimes, but generally in holes where the roof has partially fallen before the gob has shot.

The writer may sum up his conclusions bearing on the ventilation of rearing mines as follows:—Use safety lamps while opening out. Make a communication with old works to the rise, if practicable to do so, as soon as possible. Do not have a level and cut-through in driving at the same time. Pay special attention to examining for gas between the face of the levels and the last open cut-through. See that the brattice sheets in which air pipes are fixed are not made too tight. If there be gas in the goaf, stop the drifts till the gob shoots.

Rearing mines are naturally adapted to the "ascensional" system of working the air, as in a majority of cases it would be difficult to ventilate in any other way to any great extent.

The subsidence of surface, caused by the working of rearing mines, is hardly included in the subject of this paper; but the writer may note, in passing, that as far as he has had the opportunity of observing, the steeper the dip is (beyond 40 degrees), the smaller is the subsidence.

The sketch No. 4 is a section of the lower rank, recently proved at the New Winning, Leycett Collieries, where, as will be seen, the strata are considerably contorted.

Sketch No. 5 is a plan showing the direction of the level in the 10ft. mine, at the H. and W. pits, Leycett Colliery.

The section across A, B shows the contortions, locally termed a "horse-back."

The writer has collected these notes, trusting that they might be of interest to the members of this society, but hardly in the expectation that they would be of much use to the few engaged in working "rearing" mines. The conditions existent at the Leycett Collieries, except as regards dip, would hardly be found in many other places, and where found would doubtless be dealt with in an efficient and possibly somewhat similar manner.

In conclusion, the writer has to express his thanks to Mr Stevenson and Mr. James Holme, of the Leycett Collieries, for the information they have kindly afforded him.

Mr. J. F. Seddon said he could not help expressing great gratification that Mr. Grimshaw had brought this subject under the notice of the members. They seemed at the Leycett Colliery to have a very large selection of inclinations—far more than he (Mr. Seddon) had supposed to have existed in Great Britain. He had paid special attention to the subject of steep mines for some years, and had visited, as he thought, all those collieries where the steepest inclinations were to be seen; but he had not visited this particular colliery, the features of which differed very materially from what he had been accustomed to—the inclinations being so irregular. His experience was that steep mining was very costly and difficult under the most favourable circumstances, but in this mine, where the dips were so various and irregular, he imagined that the persons engaged in working it had anything but a pleasant task. He would like to know from Mr. Grimshaw whether, in the balance brows, the roof was of such a nature that it would hold together without artificial support, for say 6 or 7 feet wide, as if it had to be timbered the process would be an expensive one, and one which

would hardly admit of the work going on if the timber had to be much renewed from time to time; also, whether, according to Mr. Grimshaw's experience, the 100 yards named in the paper was the practical limit, for the length of the brow, as well as, of the levels out of it. He presumed that whilst driving the balance brows up, the coals produced in them tumbled down, and found their way to the bottom as best they could; and, further asked Mr. Grimshaw how much coal per man, per day, could be produced, as compared with a mine of the same thickness and ordinary inclination.

Mr. GRIMSHAW said the balance brows were driven between 8ft. and 9ft. wide, and there was much less stress on the roof in them, generally speaking, than there was in the levels. They would stand, in the case of some mines, that width, in other mines they would not. For instance, in one place it was found requisite to have very strong cross pieces, across the brow, let into the coal on each side. It was impossible to prop under them, and in the case of a roof that would not stand, it was necessary to curtail the width of these brows. In some cases that had been done; but the practice differed with every mine that was worked. A hundred yards was the limit to which a balance brow could be worked to take the coal from the levels—taking them every ten or twelve yards. A balance brow of 100 yards in good working order would not deliver more than 300 tubs in ten hours. Getting back was not at all regular work, it was all shot work, and sometimes a shot would bring very little, whilst at other times it would bring down 50 to 60 tubs of coal. A collier would, he thought, on an average, get fully as much, if not more, coal per shift in a "rearing mine" than he would in a flat one. He might mention that the levels were generally driven at a yard price, the coal not being paid for separately. He might also say that the

proportion of round coal was, as might be expected, greater in "pillaring back" than in opening out.

In reply to Mr. Martin, Mr. GRIMSHAW said the limit of 100 yards in the levels was on account of the price paid for way-drawing. The limit of the length of the brow itself varies somewhat according to the dip, but where the dip was 45 to 50 degrees, the distance was limited by the amount of work that could be done in the brow.

Mr. MARTIN said that in "rearing mines" with which he had been connected, some of the balance brows extended to 150 or 160 yards; the levels, which were set off about 10 or 11 yards apart, were, however, not generally all at work at the same time. The distances between the brows varied very considerably according to circumstances, and, in some cases, were as much as 500 yards. The length of level worked on one side from a brow varied from 100 to 400 yards. This was, however, a matter which depended on the respective mines and the local circumstances. The making of brows in such mines was very expensive and require a considerable time, more especially where the dip was from 30 to 60 degrees, and the coal so soft as to require props under the cross pieces. The character of the roof and floor and regularity of the dip, plays an important part, in deciding whether the maintenance of short levels, with a low "putting" price, but with increased outlay in making brows ready, or the maintenance of long levels with a higher "putting" price, but with reduced outlay in making brows ready. &c., is the most profitable. In the mines to which he referred, unfortunately necessity had to prove the mother of invention, as the levels had to be largely secured with timber. Referring to the mode of ventilation, he said that pipes were in some special instances used, but the forcing of the air through them was found to interfere more with the general ventilation than

was the use of half-inch deal brattice, which was largely used for temporary purposes whilst holing "cut throughs" between the levels. This plan admitted of a larger area being available for the circulation of air, which was most desirable; as, in accordance with the area, and the length of pipes, &c., through which the air has to be forced, the ventilation would be additionally throttled.

Mr. GRIMSHAW mentioned that there had been cases of difficulty, in which as many as three sets of pipes were required, but he referred more particularly to the "jack holes," or "cut-throughs," driven with just room enough for the men to work in. He also spoke of not having the cloths too tight, on account of the pipes throttling the air; and mentioned also that it was better, in every case, in a "rearing mine," not to have the level and cut-through going together. He also considered that in "cutting out" lamps ought always to be used, but in "drifting" or "pillaring back" the men had a very strong objection to lamps; and from his own experience in "rearing mines" he might say that he too had a very strong objection to them.

Mr. MARTIN said that he experienced, at first, a very strong objection on the part of the men to use safety lamps, especially "Davy's;" but they overcame it in a measure by introducing Clanny lamps, and after a short time, when the men became used to them, there was no further objection raised.

The CHAIRMAN said that Mr. Grimshaw's paper was an eminently practical one, and one that must be of use to many members of the society. The larger proportion of the mining members were connected with mines dipping at a moderate angle, but some of the mines are steep. For instance, in the neighbourhood of Manchester the dip did not exceed perhaps one in two and a half, and the average was perhaps one in three and a half. At the eastern out-crop—near Ashton-

under-Lyne, and on the Cheshire side—the mines at the out-crop were almost as steep as those in North Staffordshire; and on the northern part, about Great Harwood, they dipped at an angle of about 60 degrees, and at the out-crop the coal was perpendicular, and even at places actually overlapped itself a little. But in the principal portion of the coalfield, as about Worsley, Hulton, &c., and in the Wigan district, the angle was much flatter. The details, therefore, which Mr. Grimshaw had given them would be very useful to mining engineers generally. He had pointed out in his paper, and in answer to questions, many of the difficulties that were met with; the way in which the roof would not stand when worked in certain directions; and the way in which the gob rushed back in the workings in drawing back the coal. He had also replied, in answer to a question whether such flatness of a fault as shown in his section was usual or not. Of course it was not usual in any district where the strata were lying horizontally; but in all steep strata the slope of a fault varies according to the angle at which the strata lie against it. This rule would be found universally carried out, not only in North Staffordshire but also in the steep mines of Somersetshire and in Belgium. Some faults which he had seen in Belgian mines ran perfectly horizontal, but the direction of the throw could always be ascertained by observing the angle at which the strata came against the sides of the fault. The Leycett mines he (the Chairman) visited several years ago, and, as far as his recollection served, they had been very carefully and accurately described by Mr. Grimshaw. He had also visited the Somersetshire mines, where some of the overlaps were very distinct. Also mines in Belgium where the overlaps were so distinct that, at some places, had a shaft been sunk, it would have passed through the same seam three times. In that country, where they had a very large number of steep

mines to work—some vertical and some overlapping—the universal system was the long wall. There was scarcely such a thing as working a mine by the pillar and stall, as practised in North Staffordshire. A great advantage of working these steep mines by the long wall was, that they got rid of many of the shoots of gob, which appeared to be a very serious matter in North Staffordshire. But great difficulties had to be contended with in driving out the long wall in steep mines; they had the gob or goaf above the level to support. That had to be done by setting very strong timbering, and upon that timbering putting laggings and brushwood, for the gobbings to rest upon. By the long wall process a larger proportion of large coal may usually be got, which is a great advantage.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VIII. VOL. XIV. SESSION 1876-7.

At the ORDINARY MEETING of the members, held at the House of the Literary and Philosophical Society, George Street, on Tuesday, 30th January, 1877;

Professor W. BOYD DAWKINS, M.A., F.R.S., President, in the Chair.

Mr. George Goodwin, Broomstair Colliery, Denton; Mr. William Holding, Brinsop Hall, Westhoughton; Mr. Wm. Henry Place, Hoddleston Collieries, Darwen; Mr. Thomas Tomlinson, 3, Richmond Terrace, Whitehall, London; and Mr. Thomas Edward West, 65, Werneth Hall Road, Oldham, were elected members of the Society.

THE CONDITION OF VESUVIUS IN JANUARY, 1877.

BY PROFESSOR BOYD DAWKINS, F.R.S., President.

Vesuvius, as we see from the reports of Professor Palmieri in *The Times*, "is in a fever," and may shortly be expected to be in a state of activity. While, then, we are awaiting another eruption, it seems to me worth while to record its condition as it appeared to us in the beginning of January, together with some general reflections on its history.

On starting from Naples for the top of Vesuvius you drive along a plain which is at the foot of the rising ground on which Resina stands, a densely crowded town on the site of the old Retina and that of Herculaneum, which lies deep under the accumulations of successive eruptions, the volcanic mud by which it was overwhelmed in A.D. 79 being covered by subsequent flows of lava that sweep down to the sea, and now furnish supplies of good building stone. Then you creep laboriously along the dusty road, winding between the vineyards and fig-gardens, towards the Observatory, where Professor Palmieri keeps watch and ward over Vesuvius. The vineyards are soon left behind, and we plunge into a lava stream, in some places like the ashes from an iron furnace; in other places like a swirling torrent suddenly turned into stone, and with the surface folded and twisted into most fantastic shapes. Where the fall of the ground had been great, the viscous mass had cooled into great rope-like coils. The effect of the rate of cooling and of the pressure, in altering the texture of the lava, was very well shown in some of the sections exposed by the heavy rains, where the lower part of the lava-stream, resting on a bed of ashes, was very hard and compact, while the little cavities in it increased in number and size until the surface was reached. This is due to the gases and steam imprisoned in the heated rock being unable to expand and escape, because of the pressure of the upper part. The black rugged surface of the lava fissured and crannied in every direction, the home of innumerable lizards, and with its hollows covered with a lichen which gives a whitish tint (like that of a white efflorescent salt), forms a striking contrast to the gardens close by. You could stand with one foot on a land fertile as Paradise, and with the other on a desolate treeless expanse, as barren as the dried-up region of Aden.

The Observatory, and the old Hermitage, where the car-

riages are left behind, stands on a promontory, a fragment of the ancient crater of Monte Somma, swept on either side by currents of lava from the great troubled sea of lava which has to be traversed before you get to the cone of Vesuvius, that stands in all its naked grandeur before you, with the path leading to its summit marked by a faint zig-zag line, and flecked here and there by a few patches of white in its lower parts. Its base is 2125 (Aneroid) feet above the sea. The highest point of the crater visited was 4100 feet (Aneroid) above the sea. The height, however, is constantly varying, either by the ejection of new clouds of ashes, or by its edges tumbling in. The cinder cone itself is 2050 feet from the point where it rises from the sea of lava to the summit.

The cone is composed of loose rolling cinders, compacted together here and there by veins and "dykes" of lava, and resting at an angle varying from 30 to 18 degrees. On getting out of the beaten track I observed that the coating of loose cinders was merely superficial. It conceals a strata of hard white snow, which was protected from the heat of the sun by the low conducting power of its covering. This was the case in several places in the lower two-thirds of the cone. In the upper third the heat of the mountain began to be felt, and at the top the surface was warm enough to be sensible through the thick soles of shooting boots.

The lip of the crater is a true knife edge, from which you look down into a vast precipice-girt amphitheatre, full of a yellowish-white vapour, of the consistence of a London fog, in a state of continual movement, and lit up now and then by the glare of a spurt of molten lava. A low rhythmical roaring and a continuous hissing sound pointed out the hidden seat of actual disturbance, far down below. The vapour is composed of steam, hydrochloric acid, sulphuretted hydrogen, carbonic acid, and sal ammoniac, and rose over

the lip of the crater in suffocating gusts, sufficiently acid to affect the colour of a feather worn by a lady of our party, and to render a descent into the crater for more than a few feet very dangerous. A coating of yellow sulphur, about three inches thick, covered the lip, and beneath this the loose grey ashes gave out aqueous vapour at every pore, which deposited on them in some places white powdery sulphate of lime, in others common salt, sal ammoniac, green chloride of copper, and specular iron ore, which looked like little pieces of shattered mirrors scattered through their substance. It was obvious that here we had a striking proof of the mode in which water, in passing through heated rock, can carry minerals in solution and ultimately deposit them. In these processes we could easily recognise the mode in which the various metals were brought up from deep down in the earth's crust and deposited in holes and crannies in the rocks, which are accessible to man as mineral veins. At a point a few feet within the edge of the crater the ashes were so hot about three inches from the surface as to kindle a piece of paper instantly on its being thrust in, although they looked perfectly dead and black. At a very little depth the heat must be enormous.

According to the last accounts, the signs of an approaching eruption are increasing. The glare of the molten lava at the bottom of the crater, dimly visible to us through the vapour, is now to be seen as far off as the observatory, where Prof. Palmieri records every phase of the varying phenomena, and every throe of the Typhon (earthquake) fabled to lie buried under the roots of Vesuvius and Etna, and to be striving to rise again to the upper world.

At the time of our visit, the white vapour poured into the hollow between Vesuvius and Monte Somma, known as the Atrio del Cavallo, and looked at from the Bay of Naples rose like a tall white plume, very different from that great

towering mass which in times of eruption has been likened by all observers to the dark head of an Italian stone-pine, and still more unlike that dense cloud which arose in 1872 from the burning torrents of lava, which plunged far down the slopes, obscuring the whole of the cone of Vesuvius and of Somma in one vast towering, canopy, which was as the smoke of a fiery furnace. The mountain may be said to be now in a state of "unquiet rest."

From the tables published by Prof. Phillips (Vesuvius) it is obvious that the eruptions have, on the whole, been increasing in number since the Christian era. In the present century there have been twenty-five; in the eighteenth, twenty-three; in the seventeenth, four; while in the remaining sixteen there have only been fourteen altogether, which gives an average of less than one per century. The inhabitants therefore of the surrounding district may reasonably look forward to an eruption at least once every three or four years, if the extreme of the present century be only taken into account. And since that of 1872 was the last, the next is now over-due, and may be expected at such time as the column of lava can be raised sufficiently high in the crater to burst through the sides and flow over the surface, as it threatened to do in 1876, and is threatening now. We may view it as the safety valve of the whole volcanic district around, through which those forces find ventilation, which, otherwise pent up and accumulated, would ultimately result in a stupendous destruction like the first on record. In former times they found vent in several places in the district. The Phlegræan Fields are full of volcanic craters, as close together as those which pit the surface of the moon. That of Monte Agnano still gives off vast volumes of vapour containing sulphur and sal-ammoniac, and of carbonic acid gas that blows out of the vent named, after the unhappy dog thrown into it to satisfy

the cruel curiosity of visitors, the Grotto del Cane. That of the Solfatara is said to have been in eruption in the middle ages, and now gives off steam charged with various minerals, which rushes upwards as if from a gigantic subterranean boiler, and pours up vast quantities of fine volcanic mud, which is familiar to many in the shape of medallions, and cameos, and other ornaments made of "lava." The Monte Nuovo, a cone 440 feet high, raised on the site of a valley in the short space of three days, in 1538, filling up part of the Lucrine Lake, and now, without any trace of activity, proves that underneath this region forces lie dormant which from time to time assert themselves with tremendous energy, and need some safety valve, that they may be prevented from accumulating. The present chronic activity of Vesuvius, therefore, may be viewed as very fortunate for the inhabitants of the district, although it has a very different aspect to the dwellers on its sides, who have to seek compensation from the Government for burnt vines and gardens spoilt by the fine ashes and acid vapours, which affect the vegetation as badly as the fumes from alkali works.

The Vesuvius of to-day is altogether a different mountain to that which was known to the classical writers. The earliest mention of it is connected with the Servile Wars, provoked by the ruthless oppression of the Romans. We are told by Florus that the gallant swordsman, Spartacus, took refuge with his band, B.C. 72, within the crater, which was then in form very much like that of the amphitheatre in which he had so frequently been victorious. "*Prima recut arena viris Mons Vesuvius placuit,*" writes Florus, with singular fitness. The level bottom was the arena or stage, and the lofty precipices by which it was surrounded would aptly recall to the minds of the gladiators the rows of seats rising tier above tier, from which the spectators admired their struggles to the death. It was, indeed, the most

appropriate place for raising the standard of rebellion. Besieged here by Clodius Glabrus, the Prætor, he scaled the precipices by means of ladders made by wild vines twisted together, and surprised and routed his besiegers. From this account it is evident that then the crater was clothed with vegetation, and that the fires within were then not kindled. Nevertheless, Diodorus Simlus, writing twenty-seven years afterwards, remarks that it bore "many marks of having emitted fires in ancient times, and Pompeii itself is built upon the *debris* of an ancient prehistoric eruption." This crater, however, of Spartacus is not to be confounded with the crater of modern times, which is a variable heap, thrown up from time to time, and again, not seldom, by a greater effort of the same force, tossed away into the air and scattered in clouds of dust over far-away countries. It is represented by the ruined crater of Monte Somma, as pointed out by Sir W. Hamilton and Professor Phillips, which was reduced to its present state by the first-recorded eruption, A.D. 79, of which Pliny the younger has given us an account valuable in many ways.

As the result of this memorable eruption, the side of the mountain which faced towards the south-west, that is to say, in the direction of the three overwhelmed cities, was destroyed, while to the north the precipices of Monte Somma mark the site of the ancient crater. To the south-west it has been obliterated to a great extent by repeated eruptions, but its form may be traced with considerable accuracy by the break in the contour of the mountain, which is known as the Pedimentina. The ancient crater of Vesuvius known to Spartacus is now to be sought principally in the *débris* which has covered up the ruined cities of the plain and filled up the sea for at least a mile away from its ancient coast. From that time the shape of the mountain has been changed by the successive eruptions, and the greater part of

the top of the present cone has been built up since the year 1843.

Mr. A. W. WATERS said that last winter, when in Naples, he went twice to Vesuvius. On the first occasion the mountain was comparatively quiet, and he was able to descend into the crater. Of course there was a good deal of gas and vapour all round the top which was unpleasant to pass through, and there was the same lower down, but at times the smoke blew away and they were able to see the opening quite distinctly. He stood, probably, 20 or 30 feet from the opening, and looking down into it. That opening is slightly eccentric, and alters constantly. About six weeks after I had been up Vesuvius the first time, the siesmograph of Professor Palmieri showed movements going on below, and shortly after there was an earthquake, which caused a good deal of excitement in Naples; the lava rose in the cone, and it was thought there would be an eruption. It rose so far as to cause the smoke to be slightly coloured at night, but there was nothing further than that, although it was reported in some English papers that there had been an eruption. About that time he went up again. Then it was, of course, impossible to go down into the crater, but the day he went up he did not find that there was as much activity observable as he had expected; he heard hardly any noise when he was standing up, and it was only by lying down and placing his ear on the ground that he could hear slight rumbling below. The surface was considerably hotter, and he was able to get a stick to burn much more readily than on the occasion of his first visit. With regard to any coming eruption, too much reliance should not be placed upon reports. The movement shown by Professor Palmieri's instrument indicated that there was great likelihood of one, but further than that it was impossible to say

anything, although the movement might result in the lava rising, as it did last year, not sufficiently, however, to cause an eruption. Each year the most was made of any movement, especially about the beginning of January, when they wanted to attract all the visitors they could to Naples. Professor Dawkins had scarcely touched upon the general phenomena of volcanos, but he had pointed out that all the cone of Vesuvius was above the level of the sea. But the greater part of the volcanic formations around Naples had, on the contrary, been formed under water—not Vesuvius itself, but nearly all the tuffs in the neighbourhood of Naples, and around the Phlegræan Fields; all these had been formed by volcanos when that district was under water. Very recently he (Mr. Waters) heard Professor Carpenter declare, in the course of a lecture, that these tuffs were regularly stratified, and that if he had not examined them he should have believed that they had been deposited under water. They had been so deposited, and the strata contained shells of species which were now found living in the Bay of Naples.

AMBULANCES FOR COLLIERIES.

Mr. Dickinson said he had received a letter from Sir Edmund Lechmere, on the subject of ambulances for collieries, with a request that he would bring it before the Society, in order that it might receive the attention of the mining public. He believed that few, if any, of the collieries in this district were provided with special appliances for the removal of injured persons.

Some drawings which accompanied Sir E. Lechmere's communication were exhibited, showing an arrangement which, Mr. Dickinson said, seemed to be very complete.

A DESCRIPTION OF THE SINKING THROUGH THE QUICKSAND AND OTHER DEPOSITS OVERLYING THE METALS AT ROYTON, LANCASHIRE.

By Walter Evans.

There is no doubt that in many districts where the metals are covered with a considerable thickness of quicksand, &c., that sinking through these deposits has been, and will be, avoided as long as possible, owing to the difficulties expected to be encountered when sinking through deposits of this nature is commenced. The time is quickly coming when these difficulties will have to be faced; they are of no trivial character, and cannot receive too much consideration from those who are likely to have such sinkings to contend with. This, then, is my reason for bringing before this Society the present subject, in the hope that the description of the sinking in question, though containing nothing new to many of the members, will, at least, be interesting to some of them.

The following is a section of the hole bored before sinking was commenced, and though it is not of a very inviting character, from former holes which had been bored it was considered to present the most favourable section, and was therefore chosen for the site of the sinking. The surface at the top of the bore hole was 500 feet above the sea level:—

Peat	1	2	0	Soft Marl	1	1	10
White Loam and Quicksand ..	2	0	3	Quicksand	2	0	2
Quicksand and Loam	4	0	9	Soft Marl	0	1	6
Quicksand	1	0	0	Quicksand	5	2	6
				Sandy Gravel ..	0	1	6
				Quicksand	0	1	6

Soft Marl.....	0	1	3	Loam	0	2	8
Quicksand and				Gravel and Loam	0	2	0
Loam	0	2	6	Marl and Loam..	0	2	2
Quicksand	1	0	3	Marl.....	0	0	11
Brown Marl....	27	2	0	Strong Gravel ..	0	1	0
Soft Loam	0	1	3	Marl.....	0	2	0
Quicksand and				Marl and Loam..	4	1	5
Loam	0	1	3		59	0	8
Marl.....	0	2	0				

The preparations made for hanging the pit were as follows:—

Four balks of pitch pine were placed parallel to each other at such distances as to allow ten hangers to be placed in the pit without their passing through these timbers. The beams were doubled in depth, now measuring 60 feet long, 18 inches broad, and 36 inches deep. The ends were laid upon sleepers, short struts were placed from beam to beam, and through these the hangers passed. By these means the weakening of the main timbers by boring through them was avoided. The whole of the timbers were firmly braced together, and the head gear fixed upon the top of them.

The engines for pumping and winding during sinking operations were placed upon timber foundations some 50 yards away from the pit. The drums used in this sinking were composed of cast iron segments, of about four feet deep, eight to ten of them, according to the diameter, forming the circle. The metal was $1\frac{3}{4}$ inches thick, and the flanges 5 inches deep from front to back. The circular flanges had 6 bolt holes, and were strengthened by a good bracket between each of them. The upright flanges had 5 bolt holes, between each of which a strengthening rib ran from side to side of the segment, coming flush up with the flanges. The segments were bolted together with bolts an inch in diameter, soft wood $\frac{1}{8}$ inch liners making the joint.

The leading round of each drum was bevelled at the bottom edge to about $\frac{3}{4}$ of an inch thick, forming what is generally known as a cutter.

Wet quicksand having been met with at 9 feet from the surface, it was decided to commence running the drums at once. The cutting round was therefore placed in position, and held by means of iron hangers $1\frac{7}{8}$ inches in diameter, upon the upper ends of which were chased a long screw thread. These passed through the timbers provided for hanging purposes, and which have been before described. Large square nuts, upon good wrought iron washers, held the hangers in their places. The nuts were now slackened, and the drum forced into the sand for about 3 feet, and built up to 12 feet long, each round of castings breaking joint with the one before it. The drum was kept straight by means of the hangers, those being held tight on the side which was shown by plumb lines hung from the flanges to be the lowest. It was soon found that the weight of the castings alone was insufficient to cause the drum to sink further into the sand. Extra weight was therefore added, and the cutter now reached a depth of 16 feet from the surface. The sand had been allowed to remain about 7 feet deep in the pit, and we commenced to fill a portion of this out, as the drum seemed wedged fast. When about 3 feet had been cleared, sand and water rapidly filled up the shaft for 11 feet. This drum had a length of 20 feet, and had reached a depth of 18 feet; this was increased to 20 feet, the sand being kept out to within 6 feet of the cutter. It now boiled up again in large quantities, and in a very short time had risen up the castings to a depth of 13 feet, and caused several of the holes through which the hangers were secured to break out, which allowed the drum to cant over considerably. The weight was eased on the lower and placed upon the higher side, and the

castings gradually brought over to the perpendicular again. The sand and water now became exceedingly troublesome, often rising in pushes of from 6 to 10 feet at a time. The drum was forced down to a depth of 25 feet from the surface, when we were again driven back by the sand about 17 feet. Several of the segments were now cracked, and the bolts were continually breaking.

A fresh drum was, therefore, placed in the inside of the last one, and run without much difficulty to a depth of 39 feet 4 inches from the surface; but the sand again suddenly rose, and filled up the shaft for 20 feet. This drum was lengthened to 40 feet, and would weigh alone between 50 and 60 tons. The hanging beams and head gear were placed upon the top of it, and all the available space inside weighted. The beams were mined under the ends, care being taken to only just keep them clear, so that if at any time the drum showed signs of canting over the beams could be packed under, and its progress arrested by the application of the hangers. Jacks were also applied to the top of the drum, forcing against the first one. The total weight now acting to force down this drum could not be less than 220 tons.

Even with this weight the process was very slow and tedious, and when a depth of 45 was reached the sand again filled up the pit 22 feet. Several segments in this drum were now cracked, and the breaking of the bolts was an every day occurrence. Sinking operations were stopped for some time to enable us to drain down, if possible, the head of water at the back of the castings. When sinking was begun again the sand stood 25 feet up the pit, and we commenced filling it out, but could not reach nearer to the bottom of the drum than 10 feet, and any attempt to do so was met with sand and water rising to a much greater height. It was found that with this depth of sand in the

drum it could not be moved, and also that if about 30 feet of water was allowed to remain on the top of the sand the latter remained comparatively quiet. The following plan to deal with the sand under these circumstances was therefore hit upon, for these frequent sudden risings of sand, or "blows," as they are locally termed, greatly endangered the safety of the drum. The machine used was of a rather primitive character, but its complete success must be my excuse for entering into a full description of it:—An old boiler flue, which was lying about, was fitted at the bottom end with clacks, hinged in the middle. These were held horizontally by chains wound round a cross shaft, running through the tube, from side to side, some 4 feet 6 inches from the bottom. This shaft was prevented from slipping round by a catch which fitted on to one end of it. The other end was made square, to receive a loose handle. On the top of the flue were riveted three sockets, and also three chains, by which it was attached to the winding-rope. When the top of the tube was lowered to the top of the water, iron bars were inserted in the sockets, of such length as to allow about 6 feet of them to remain above water when the machine reached the sand. A platform was placed in the pit, and upon this the workman stood, who, when the tube had reached the sand, commenced shaking it from side to side, causing it gradually to sink to a depth of some 4 feet. The machine was then wound out, the water finding egress through holes cut in the side of the flue. The banking wagon having been run over the pit the catch was knocked off, allowing the clacks to drop, and the sand to fall out. The clacks were now wound up to their proper position by means of the handle, the catch applied, and the tube sent down again.

By these means we were enabled to considerably lessen the resistance to the sinking of the drum, and succeeded in reaching a depth from the surface of 55 feet.

Bolts in this drum were now daily breaking. Another one was ordered, and was run to a depth of 60 feet by means of jacks, of the united nominal power of 120 tons.

The weight of this drum would be about 80 tons. The inside of it, where possible, was weighted with bricks and castings, and the whole forced down to a depth of 67 feet from the surface. The sand, which for some time had remained pretty quiet, often rose in considerable quantities; but when a depth of 75 feet was gained all seemed still again, and as marl in the bore hole was reached at 66 feet down, and the drum had for some time required a pressure of no less than 480 tons to move it, and now ceased to run, we considered that the marl had been reached, and commenced to pump out the water, substantially propping the drum as it was lowered. Having got to within 15 feet of the cutter the water was observed to be rising rapidly. It was accompanied with sand, which, with surprising rapidity, rose 34 feet up the castings, water rising to a still greater height. Several segments also broke. It was found by boring that the marl under the sand had a dip of about 1 in 1, and that the drum had passed through a considerable thickness of it on the higher side. Drum No. 4 was now put in, and as we were able to keep the cutter pretty free from sand by means of the machine before mentioned, a depth of 78 feet was reached, when the soft side was piled out, and a way cut for the drum in the hard marl on the other one. The depth of 83 feet was reached, and good marl found all round the shaft. The sand, &c., was cleared out, and the drum made up with short castings about 2 feet 6 inches long, and 1 foot 6 inches deep, special measure being taken for the last piece. The plan shows the manner of making up the drum, the space between it, and these pieces being firmly wedged. Short castings were carried to a depth of 89 feet. The sinking forward was now commenced, and the marl being

strong, brickwork was put in in short lengths. The bricks were 12 inches long, and made taper to fit the circle. They were put in endways, and set in Ardwick lime and cement.

Each ring was bolted to the one above it by bolts an inch in diameter, twenty of them being used in a round. When a depth of 100 feet had been reached, in cutting for the next length a gravel parting was met with, out of which water oozed slowly.

Before this could be made good the water burst through, bringing with it sand, which filled up the shaft for 50 feet, 10 feet of water remaining on the top of it. On this being got down again the brickwork was found to be almost ground to powder. It was now decided to carry castings forward. At 107 feet the marl commenced lifting under foot. Ten feet was bored down to ascertain the cause. We were, however, forced to leave it. The bottom broke up, sand rose 47 feet, and water 70 feet. We got down now without any serious drawback to within 15 feet of the bottom of the marl. A bore hole was put down, up which water rushed, rising to a height of between 80 and 90 feet, sand in this case only rising 10 feet. We got through the remaining distance without much difficulty, with two drums constructed, and run in the same manner as those previously described. The metals were reached at a depth of 176 feet 6 inches, by a pit 11 feet 4 inches diameter, the sinking of which had taken from July, 1871, to January, 1874.

The quantity of water met with in the sinking of course varied considerably. At the commencement it was 2,100 gallons per hour, and during the running of the last or No. 6 drum 12,800 gallons per hour.

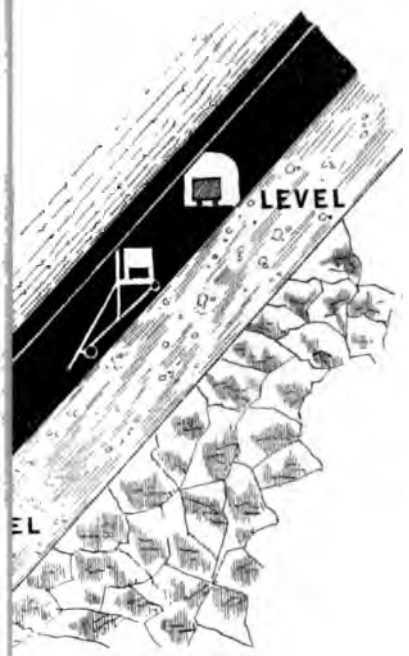
Mr. TOPPING said he had, unfortunately, some experience in sinking through quicksand. One pit was sunk through 22 yards of quicksand, with 3 yards of marl

between; and another through 31 yards of sand with 4 yards of marl. In the sand they sank, on an average, 1 yard in 12 hours without difficulty. Having passed through the marl, and penetrated the second sand, it was found that the marl pressed in with great force, and turned up the edge of the cutter 2 feet from the vertical position. A second curb was then put in. He thought it was best not to use cutters at all; they were merely a source of weakness, as the chief difficulty lay in making the bottom of the curb secure, and other segments could not be bolted on.

Mr. GRIMSHAW said in one case he was connected with the pit was carried through the sand, and 4 feet into the marl. A borehole was then put down on to what was supposed to be the stonehead. The curbs were then secured. When sinking was resumed sand was met with in on one side of the pit, and came up. Piling was resorted to, and it was found that a tongue of sand jutted into the marl on one side of the pit, but did not continue across it. In the same pit a bed of sand containing large boulders was met with, and considerable difficulty was experienced in keeping the cutters vertical.

Mr. MARTIN said he had seen sinking walls used in Germany instead of cylinders, either of timber or cast iron, and had himself used one for sinking through 10 or 12 yards of quicksand. The brickwork is built on a crib of timber or iron, provided with a cutter on the outer edge, and is built up every 5 or 6 feet as the wall sinks. It is all firmly bolted down to the crib, the outer side being lined with inch or inch and quarter deals to facilitate its sliding down. The manipulation is similar to cases where cast iron cylinders are used. 40 to 50 yards of quicksand have been successfully penetrated with large shafts by such means, the walls

varying from 2½ feet to 4 feet in thickness. Dredging by means of strong canvass or leather bags, fastened to semi-circular cutters at the end of long poles, has also been advantageously used where the sand was very quick.



F BALANCE BROW

ft to an Inch.

Nº 2

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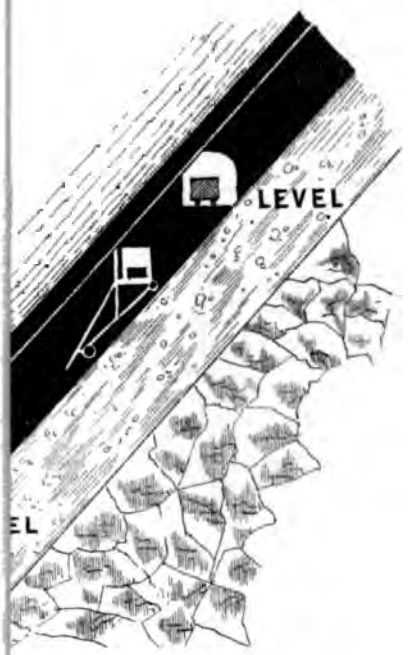

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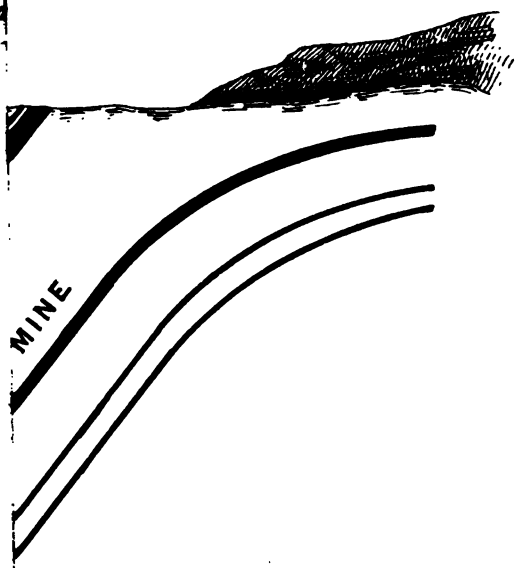

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CETT COLLIERY.

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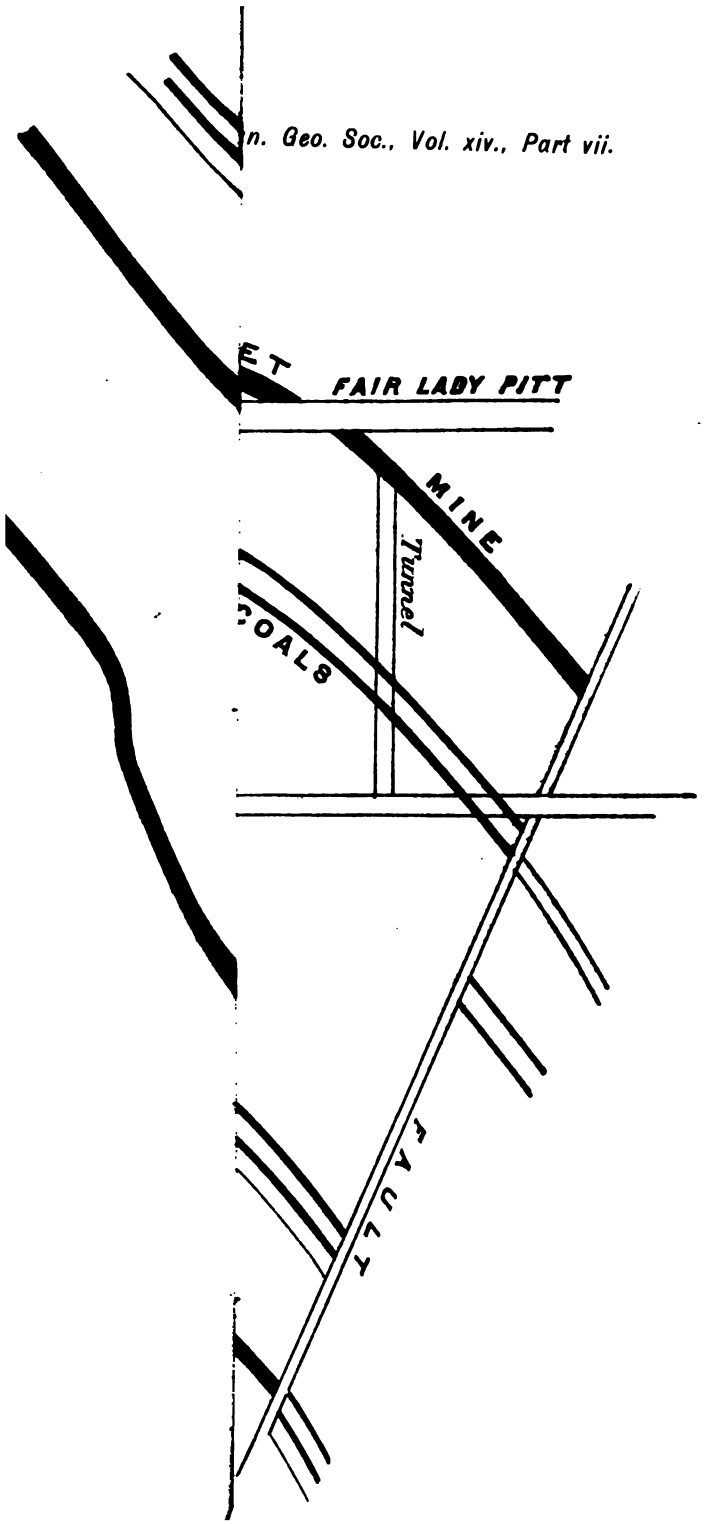
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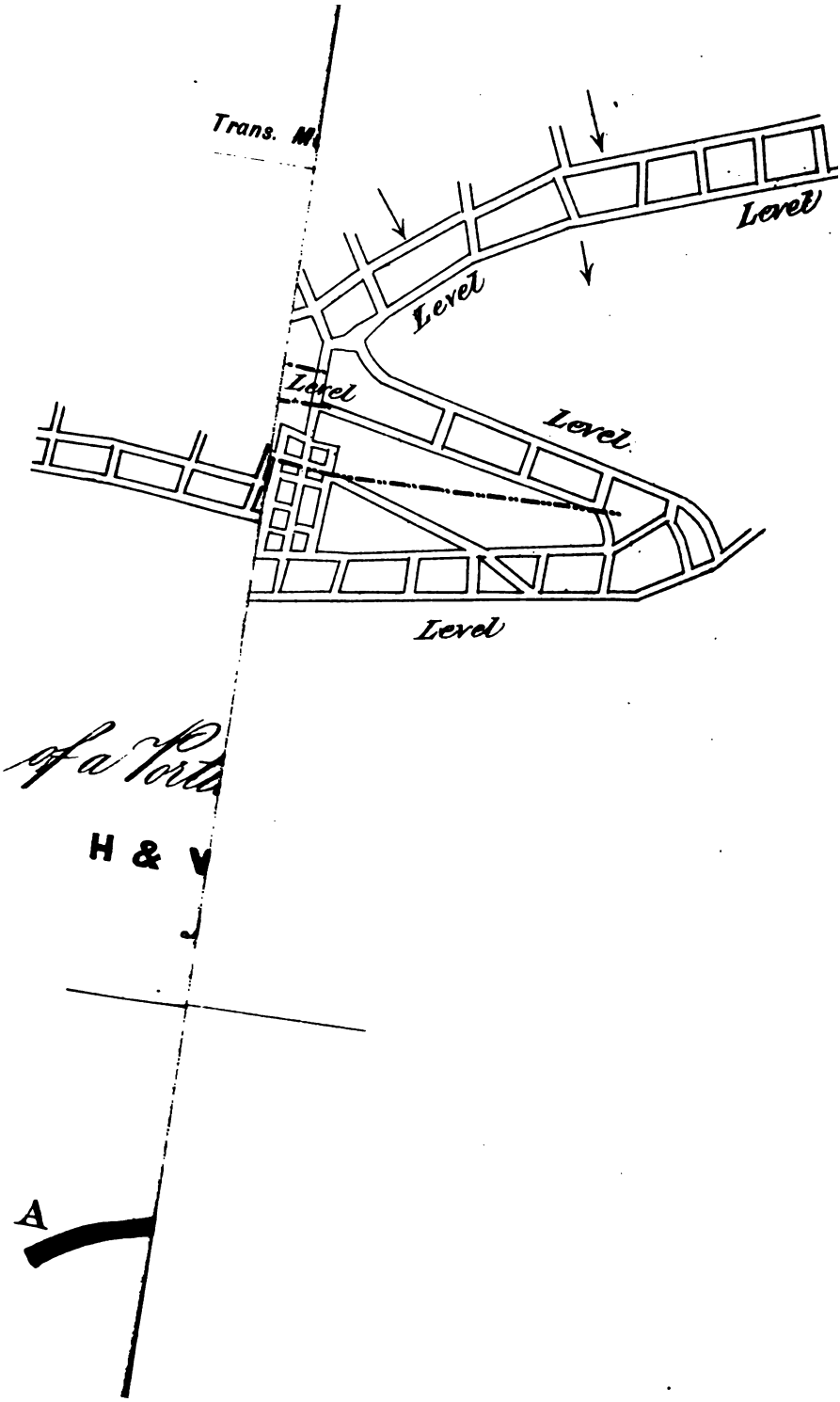
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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IX. VOL. XIV. SESSION 1876-7.

At the ORDINARY MEETING of the members, held at the House of the Literary and Philosophical Society, George Street, on Tuesday, 27th February, 1877;

Professor W. BOYD DAWKINS, M.A., F.R.S., President, in the Chair.

Mr. Thomas Meyrick Yates, Park Hall Colliery, Horwich Junction, near Bolton, was elected an ordinary member of the Society.

ON THE FREQUENT ALTERATION OF CALCAREOUS FOSSILIFEROUS SANDS TO UNFOSSILIFEROUS BEDS, BY THE INFILTRATION OF WATER.

BY A. W. WATERS, F.G.S.

When in Brussels, a few years ago, M. Ernest Vanden Broeck pointed out to me some very important and clear cases, notice of which he has since published, together with a notice from M. G. Dewalque, in the "Annales de la Société Geologique de Belgique," tom. I., 1874. He shows that the greenish yellow unfossiliferous sand overlying the calcareous sands full of foraminifera and other fossils at the base, is caused by acid water superficially dissolving out

the calcareous matter, and staining the sand by the contained iron.

Here the altered beds lie irregularly on the fossiliferous sands, and have been described by most of the leading geological authors (among others, Lyell) who have written on the Belgium tertiaries, as being Laekenien (Barton clay) deposited upon Bruxellien (Bracklesham beds), which it was supposed had been much denuded; and this has led to the fossil fruit beds being classified as younger than they should be, as these and other vegetable remains do not disappear with the infiltration of the water, and indeed, in some cases, they are silicified.

The false interpretation of these unfossiliferous sands has led to incorrect stratigraphical conclusions, and to very false views on the changes which took place in the Belgium tertiaries; for instead of erosion having removed some of the deposit in the Bruxellien period, the beds were steadily formed without any apparent break.

Since the paper on these Brussels beds, M. Vanden Broeck has, in "Esquisse Géologique et Palæontologique des depôts pliocènes des environs d'Anvers," 1876, shown that the same phenomena occurs frequently in the North Belgium pliocene, where it has been interpreted in the same way as indicating great erosion. And the same author, in a paper the abstract of which is published in the "Comptes Rendus," Jan., 1877, has pointed out that the diluvium rouge and the diluvium gris are merely modifications of the same beds. And in two papers read before the Geological Society of London, Nov. 8th, 1876, and just published in the new number of the Journal of Messrs. W. Whittaker, S. V. Wood, Jun., and F. W. Harmer, show "that what had been taken to be an irregular line of erosion between a certain unfossiliferous sand and the shelly Red Crag in Suffolk, was really a line of dissolution of shell, the sand being simply Red Crag deprived of its fossils through the percolation of water."

It is most important that every geologist in the field should keep such facts in view, and not too readily pronounce extensive denudation, and form unnecessary division of the strata.

THE IFTON RHYN COAL BEDS IN SHROPSHIRE.

Mr. DICKINSON said he observed by the last Quarterly Journal of the Geological Society of London, that Mr. D. C. Davies, F.G.S., of Oswestry, had read a very elaborate paper on the position of the coal field at Ifton Rhyn, Shropshire. Some time ago, the subject had been brought under the notice of the Manchester Geological Society, in a paper under the name of "Coal Beds in the Permian;" and, in his more recent paper, Mr. Davies adhered to the view formerly expressed, that all these coal seams were in the Permian. Mr. Davies had gone into great detail, and his paper was accompanied by a number of exceedingly useful sections. He had tabulated them, taking as his datum line the *spirorbis* limestone. To a great extent, he believed, they were correctly tabulated; but the Ifton Rhyn section was, he (Mr. Dickinson) had no hesitation in saying, incorrectly placed. No discussion seemed to have arisen on Mr. Davies' paper—at any rate, if there was any it was not recorded. This was unfortunate, because Mr. Davies had taken a wrong datum for the whole coal field. In the first place, he did not give more than one-half the thickness of the coal field that there should be. There was very little question but that the North Wales coal field was connected with the Lancashire and also with the North Staffordshire coal field, underneath the overlying Permian and new red sandstone. The whole ground for his placing the Ifton Rhyn section in that table, was that he had found *spirorbis* fossils in some calcareous beds, not far from Wynnstay.

Fossils were a very useful, but not an infallible guide, and he (Mr. Dickinson) was sorry that Mr. Davies should have been misled with regard to the position of that field, as he had been, simply through taking fossils as his sole data, and not being guided by a broader view of the great thickness of the coal field, which would have kept him right. What Mr. Davies had taken as the Permian was simply one of the beds of red ground which were to be seen on the top of the North Wales coal field and in the middle of the North Staffordshire coal field, and such as are to be found in the Lancashire coal field.

The PRESIDENT said he was sure no one was better qualified to give an opinion than Mr. Dickinson on a point of that sort. He he would like Mr. Dickinson to be good enough to state with what division of the coal-measures he identified this particular bed. Did he consider it upper, or lower, or middle?

Mr. DICKINSON said that in his opinion the Ifton Rhyn Coal Field is the lower portions of the upper coal field of North Staffordshire, but which was denuded in the North Wales Coal Field.

The PRESIDENT said the *spirorbis* fossils were widely spread in the coal measures, and the fact of finding them certainly in any given strata would not fix the age of the strata with any great precision. The *spirorbis* was, he believed, found as low down as the lower coal measures.

IRISH DRIFTS.

By G. H. KINAHAN, M.R.I.A., &c.

The drift question is a subject more or less studied by geologists, therefore, a *resume* of what is known about the Irish drifts may be of interest to the members of the Society.

In Ireland the drifts may be classed as GLACIAL, AQUEOUS and METEORIC. The Glacial has been divided into the *Boulder-clay-drift* and the *Moraine-drift*. The Aqueous may be *Marine*, *Estuarine*, *Lacustrine*, or *Fluviatile*. A marked variety of the Meteoric is the *Æolian drift*.

GLACIAL DRIFTS.

The *Boulder-clay-drift*, called *Till* in the province of Ulster, has a more or less clayey—often limey matrix—in which are imbedded irregularly, striated polished and etched blocks and fragments, principally of the rocks in the vicinity but also associated with many pieces of foreign rocks. In places it may contain irregular pockets, patches, and channels of fine sand or gravel. It is supposed to have resulted from the general glaciations of Ireland, during the time of the Ice cap on the Northern Hemisphere. The *Moraine-drift* has a sandy-clayey matrix containing angular or sub-angular partially ice-dressed blocks and fragments of the local rocks, foreign rock fragments being of rare occurrence. It is only found in the groups of hills, or in their immediate vicinity; and when in the latter position it often overlies the Boulder-clay-drift. Between these newer and older glacial drifts it is rare to find any aqueous drifts, and when they do occur they are generally not more than a few inches thick, and rarely exceeding two or three feet. They are usually fine sand or laminated clay *(book* or *leaf-clay)*. Of the Moraine-drift, there is a remarkable rocky variety, that occurs in irregular hummocks, having in it, and on it, large angular blocks of rocks, often tons in weight. The Moraine-drifts are supposed to have been formed by local system of glaciers in the different groupes of hills, whilst the *Rocky-moraine-drift* is very similar to Clarence King's description of the drift, he found, on the dying-out glaciers of the West Pacific slopes. Local systems of glaciers seem to have existed among the hills during the time of the 300 feet sea

(Esker sea), while in the West Cork hills and in the Wicklow hills they seem to have lasted much longer, propably to the the time of the 100 *feet sea.* To these seas we will refer hereafter.

Aqueous Drifts.

The sea-formed or *Marine* drifts of Ireland are interesting and important, as they include the remarkable ridges (Celtic *Eskers*) so characteristic of the central plain of Ireland. Of the existence of Preglacial marine drifts there are no positive proofs. Usually the Boulder-clay-drift is found resting on grooved, striated, polished, and etched surfaces of rock; but Pump-sinkers say that on some occasions they find sands and gravels intervening. These must, however, be very local, as in the miles of railway and other cuttings that have been examined by the officers of the Geological Survey of Ireland, they were only found on one or two occasions, and then in such positions that possibly they were *intra*glacial not *pre*glacial. Among, and on the hills of the Queen's County, Tipperary, Clare, Galway, and Derry, we have observed gravels apparently marine; sometimes under typical Boulder-clay-drift, but more often under Moraine-drift; the latter evidently are intraglacial, while the others possibly may be preglacial.

A very common marine drift among, and in the vicinity of the groups of hills, is a *Glacialoid-drift.* This is a boulder-drift, made up of very similar materials to one or other of the glacial-drifts, but always having a distinct stratification; the materials of which it is composed having been re-arranged by, and deposited in water. This Glacialoid drift seems to be marine, on account of its extending over large areas; in some places, however, it may be lacrustrine. Usually it is made up of the mixed debris of the Boulder-clay and Moraine-drift, but in some localities as in S.W. Mayo

it is divided into two distinct members; the lower drift being the *debris* of the Boulder-clay, while above, over a denuded surface of the first, and often having parting, or thin beds of fine sand and book clay between, is a drift made up of the *debris* of the Moraine-drift.

The marine drifts, that are undoubtedly postglacial, may be divided into, the accumulations formed when the sea was about the 300 feet contour line *(Esker Sea);* when the sea margin rested for a time at about the 100 feet contour line; when the sea rested for a time at about the 25 feet contour line; and more recent drifts. This brings us to the subject of "Raised beaches;" the last, however, is too extensive to be discussed here, we will therefore, confine ourselves to a description of the drifts. The "Esker Sea" drifts are found in the country below the 300 feet contour line, or about under that level, as the sea margin, similarly to that of the present sea, varied in height. The margin of the Esker Sea will be found in places in the hills; sometimes as a shelf cut in their sides, at other times as a beach accumulation. It is extremely well marked in parts of Tyrone and Derry, forming circles of gravel and sand round the isolated drift hills so common thereabout. This has induced *tyros* in the Irish drift, to class these beaches as "middle gravels," (*i.e.*, marine gravels, marking a brake in the glacial period,) as they supposed the sands extend horizontally through the drift hills. If, however, they had examined the numerous railway and other cuttings through the drift hills, they would have found that such gravels only margin the drift hills, but never extend into them.

In some places on the low ground the Esker Sea drifts are spread out in undulating sheets, as in the County of Kildare. In places in these sheets, there is fine gravel and sand under a shingly gravel. Such sections, however, seem only to be found in narrows; like that in the valley of the Nore, at the City of Kilkenny. This is easily accounted for;

as when the waters were deep and broad, there were fine deposits accumulating; but as it shallowed and narrowed, the current became more rapid and the deposit coarser.

In many places in the central plains, between the 100 and 250 feet contours lines, sands, gravels, and shingles are piled up in ridges, or Eskers. These are best exemplified in the plain between Galway and Dublin. The formation of the Eskers is a disputed subject, but lately elsewhere,* it has been suggested that they are modifications of the banks and shoals which accumulate at the colliding and dividing of the "Flow" tide currents of the Esker Sea, similar to those that are found in the seas round Great Britain and Ireland. In the Irish Sea, in the vicinity of the Isle of Man, there is a meeting of the north and south "Flow" tide waves, or a "Head of the tide." Here the waves meet and neutralize one another; in one place forming a mass of currentless water, that "rises" and "falls," and deposits thereabouts silt and such like materials. The other "Heads of the tide," in these seas are south and east of England; in the Straits of Dover, and between Norfolk and Holland. In these places there are different results, as there the "Flow" tide waves collide and pass one another, for greater or less distances; and at their edges, or the junctions of the different currents, long banks of gravel and shingle accumulate. It is also found that long banks of gravel and shingle may form at the dividing or spliting up, of the "Flow" tide wave. This is exemplified off the south-east coast of Ireland. From Greenore Point a main current runs northward up the Irish Sea, while secondary currents branch off into Wexford Bay, and at the junction of this current, with the main current, there are long banks between Greenore and Wicklow Head. Similar results should have occured in the Esker Sea.

* "Irish Drift, Esker Sea," read before the Royal Geological Society, Ireland.

The flow tide wave entering at Galway should have sent a main current eastward to the coast between Drogheda and Dublin; while south of this current there would be a bay somewhat similarly circumstanced to Wexford bay, off which banks should form between Galway bay and the Dublin mountains, that is, in the line of country the principal eskers occupy. The various details and complications in the eskers in this tract of country can be explained either by the colliding, or the meeting of the "Flow" tide currents branching from the main, with those coming through the straits; as also the different eskers in the country to the north of the main current; such details, however, would occupy too much space if fully entered into. Drift deposit at the "heads of tides," similar to that in the vicinity of the Isle of Man, can also be observed in places; as in S. E. Wexford, where the esker drift is represented by large accumulations of fossiliferous fine sand, marl, and clay; also in some of the valleys further north; while in the County Dublin, there are thick beds of brick-clay in the esker drift. As the Esker sea shallowed these banks necessarily would be more or less denuded and modified into narrow ridges, as may be seen in many places in those portions of shoals and banks that are "awash." Similarly the eskers *par excellence* of Scotland could be accounted for. I do not, however, allude to all the drifts called *Kames*, as under that head have been described ridges of marine, lacustrine, fluviatile, and meteoric drifts.

Some observers question the marine origin of the eskers, on account of the paucity of fossils found in them; also on account of the number of ice-dressed fragments. But in many similar accumulations formed by the sea at the present day fossils are rare, as the nature of their formation and the materials they are composed of, are adverse to the preservation of fossils. The old drifts they were formed from were principally glacial, consequently,

many of the fragments in them, especially near the old drifts, ought to be ice marked. In no esker, however, are found fragments that have not also the marks of subsequent water action; similarly it might be said;—all recent accumulations that contain ice-marked fragments are glacial; some of the recent estuarine accumulations contain between 50 and 75 per cent. of glacial marked fragments.

The marine drifts more recent to those of the "Esker Sea" period are similar to the older drift, being rearranged glacial, marine, or meteoric drifts; consequently no definite rule can be laid down for distinguishing the older from the newer, except the heights at which they occur. But in the valley of Lough Corrib, north of Galway, there is a distinction, as the newer gravels are principally made up of granitic gravels, and sands, while the older are more or less limestone gravels. In this valley there is a long esker, which seems to have been piled up by the colliding of the tidal "flow" waves that entered, respectively, through Galway and Kilkierin bays, during the time of the 100 feet sea. Terraces of the newer marine drift that accumulated when the sea stood for a time respectively at about the 100 and 25 feet, contour lines are well marked in places on all the east coast of Ireland and in the associated valleys; also in the valleys of the Slaney, Barrow, Nore, Suir, and Blackwater; and to the west, especially in the valleys of Galway and Mayo.

The *Estuarine drift*, although marine, is put in a distinct class on account of its partaking in part of the nature of lacustrine and fluviatile drifts; while it is very different to those accumulated in the open sea, also, it often contains terrestrial and fresh water fossils. The latter always are well washed, sorted, and water-worn, while the estuarine drifts may be nearly similar to the drifts of which they are the *debris*, some being scarcely distinguishable from glacial drifts, while many are more or less clayey or marley. No

pre-glacial estuarine drift has been found. In the Queen's County portion of the Castlecomer tableland, in the Newtown Colliery, an intra-glacial peat was found by Mr. B. B. Edge, that probably is estuarine, as the gravel associated with it contained marine fossils.

The port-glacial estuarine drifts occur in many valleys, being respectively of the age of the Esker (300 feet), 100 feet, 25 feet, and more recent seas. Plains of estuarine drifts are often miscalled "river gravels," they being supposed to have been formed by the rivers that flows in them. A little consideration, however, will show the error in such a supposition. All estuaries, but especially those that are long and narrow, which was a very general character during the time of the Esker, 100, and 25 seas, form two distinct terraces; one nearly horizontal, that marks the shore or margin of the estuary; and the other sloping more or less from the tidal strand at the head of the estuary to its mouth, the latter being the bottom accumulation. If the land rose the bottom accumulation would form a sloping plain with a river flowing through it. This plain is said to have been formed by the river, because it slopes with it and because the fossils may be, for the most part, terrestrial or fresh water. Rivers, however, rarely form a sloping plain; as the floods form ridges, knolls, and other irregular accumulations in the valley. Furthermore, fossil rarely are deposited in river accumulation, as they, generally, are carried down by the floods to the lakes, estuaries, or other still waters. In Ireland fluviatile action has in general added a little to the surface of the estuarine plains; or during floods in the immediate vicinity of the river channel, parts of the flats may be cut away, and the materials be re-arranged, but all the extensive flats adjoining the rivers were originally formed by the waters of estuaries or lakes.

In the Slaney River valley these estuarine drifts are well seen; those belonging to the 25 feet sea being found up the

valley to about half-way between Enniscorthy and Newtownbarry; the drift of the 100 feet sea to Clonegal, in the County Carlow; and those of the Esker sea nearly to Stratford, in the County Wicklow. During the latter time a bar of drift formed east of Tullow, in the County Carlow; this diverted the waters into the valley at Clonegal, through the Carlow and Wicklow hills; as prior to that time the upper part of the valley of the Slaney seems to have belonged to the watertable of the Barrow.

There are also estuarine accumulations that were deposited betweeen the time of the 100 and 25 feet sea beaches; these are now submerged 30 or more feet below the present sea levels. Such accumulations seems to consist principally of marl, clay, sand, and peat. Some of the estuarine deposited like those in the estuary of the Shannon are remarkable from the quantities of bones of the Megaceros Hibernian and other terrestrial animule found in them. Many of the estuarine accumlation that contain ice worked fragments, have erroneously been called "Upper Glacial Drift," the associated estuarine gravels being called "Middle gravels."

Of the drifts due to lakes or the *Lacustrine drift*, some are said to be preglacial. In the province of Ulster, in the Lough Neagh basin, there are plaustic clays and sands associated with beds of lignyte and silicified wood, which Mr. E. T. Hardman estimates to be at least 500 feet thick, some of the beds containing terrestrial and fresh water fossils. These accumulations in places rest on the Tertiary Doleryte of the country, and are said to have been found under the "Till." The latter, however, does not appear to me to be satisfactorily proved, as the natives of the country called the drift on it "Bastard Till," and what I saw appeared to be re-arranged or glacialoid drift. There is, however, such a great thickness of the clays, &c., that possibly part, at least, of the accumulation may be intraglacial. It seems evident that at one time the water from this lake either

flowed southward into Carlingford Lough, or south-eastward into Belfast Lough, and that subsequently, drift accumulation changed the direction of the flow, and forced the water to run northward; at what time this stoppage occurred has not been proved.

Near Cahir, county Tipperary, there is a small deposit of plaustic clay, sands, and lignyte, that seems to be intraglacical, while in the same county, near Nenagh, Mr. Wilkinson has found an intraglacial peat that probably is lacustrine. In the Boleyneendorrish river valley, near Gort, county Galway, there are plant beds and clays under glacial drift; the latter are probably lacrustrine, and evidently intraglacial.

The sites of post glacial lakes are numerous, but most of them are now filled by deep accumulations of peat and marl.

In places in the glacial drift are sinuous channels with branches from them, filled with fluviatile shingle, gravel, and sand. Such channels probably were formed by rivers, that, as Dana suggests, flowed under or in the ice. The post glacial fluviatile drift occurs in the mountain valleys and in the low valleys associated with the ancient estuarine gravels. It is remarkable in connection with the Irish rivers that not one of the larger ones forms a delta at the sea; most of the *debris* brought down by them being deposited along their courses, so that the margin of the channel of many, is higher than the flat through which they flow.

Some of the fluviatile drifts occur under deep accumulations of meteorical drift; this seems to be the case of the "Gold sand" of the County Wicklow. As before stated the glaciers seem to have continued longer among the Wicklow hills than in most of the other Irish hill groups. This is surmised, because in the Ovoca valley the Esker sea gravels do not appear to occur. There are some gravels that possibly may belong to the 100 feet sea, but the 25 feet and newer estuarine gravels are well represented. Higher up

among the hills, in the Avonmore valley, there are peculiar gravels of different origins, some possibly of the age of the Esker sea; these, however, have still to be properly examined. While the glaciers were disappearing off these hills, torrents rushed down the different ravines forming drifts, of which the very lower portions were ferriferous auriferous sands (*"black sands"*); while the overlying sand and gravel contained many ice-dressed blocks, but all more or less water worn. After the ice had melted the torrent left the ravines, and their sides weathered into slopes, thus covering the fluviatile drift for a greater or less depth with meteoric; whether the gold drift extends under the 20 feet estuarine drift of the Ovoca valley has not as yet been proved.

The Fluviatile drift now forming has produced deltas or "srahs" in many of the lake basins, also well-defined ridges and hills on the estuarine flats. The ridges seem due to sudden and great floods going through a narrow, or gorge, on to a flat; as similar ridges on a small scale may be made by letting a rush of muddy water through a doorway into a room. Such sudden floods must have been of frequent occurrence prior to the climate becoming as temperate as now. During the historical period, from time to time they are recorded in the annals, and one occurred in the Ovoca river as late as March, 1867. This flood was not due to heavy rains, but to a heavy fall of snow in the highlands. This remained longer than usual, giving time for lakes or ponds of water to accumulate in the valleys behind the snow drifts. When the thaw came these lakes burst all at once, the water rising in the valley from 10 to 15 feet higher than the ordinary excessive floods.

Meteoric Drift.

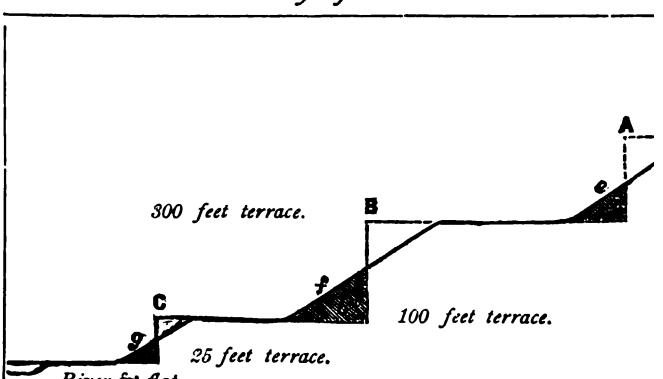
The drifts due to weathering are considerable in Ireland, although little notice has been taken of them. As the ice sheet, and subsequently the local systems of glaciers, melted away the meteoric abrasions must have been excessive, not

only on account of the surface of the ground being devoid of vegetation, but also on account of the excess of water trickling down every slope of ground. Besides the drift due to weathering, there are vast accumulations of *Æolian* or wind-formed drift.

In portions of the low lands in Ulster under the Till, and in a few places under the Boulder-clay-drift in Galway and elsewhere, there is a greater or less thickness of angular *debris* of rock, called *broken shelf* by the miner, and *foundations* or *rubble* by the quarryman. These seem to be pre-glacial meteoric formations. In the south of Ireland, especially in parts of Cork, Waterford, and Wexford, there are large, and in places thick, accumulations of an angular drift, characterised in general for having most of the contained rock fragments standing more or less on edge. If we examine drifts that are in process of formation, we find that at corners and curls in rivers the pebble may be on edge; and in estuarine deposits near the margin, in eddies, or where slips of the adjoining cliffs take place, the pebbles are on edge; and in marine drift if a slip takes place from a cliff, the disturbed drift may be forced up on edge; while we may suppose that floating ice grounding on drift would have a similar effect. These, however, are all local or exceptional cases; we may, therefore, believe that the drifts just mentioned are meteoric, formed while the ice was disappearing. In the county Carlow, we find on the hills near Borris, that this drift is thin, but that it thickens as we go to the base of the hills, and that afterward it again thins, as it is followed out on to the estuarine gravels of the valley of the Barrow. In this valley the meteoric drift has been called erroneously "upper glacial drift," and the estuarine gravels "middle gravels." In the same county, but on the north slope of mount Leinster, there is a great thickness of meteoric drift, that in one place tails out over a recent bog, from four to five feet to a few inches deep. On the

south coast of Wexford a limekiln has been smothe meteoric drift, and the recent meteoric drift ove identical in every particular with the meteoric drif further west forms cliffs from twenty to nearly a h feet high.* A very puzzling variety of meteoric dri meteoric slopes that have been formed out of the weat of ancient cliffs of glacial drift. In artificial works as those for railways, after the new ground has had t consolidate, it is extremely difficult to point out the boundary between the old drift and the artificial Similarly with these meteoric drifts, it is hard to disti them from the old drift, except that the fragments in if flatish, have a tendency to stand on edge. The est gravels of many of the Irish river valleys are more covered with such talii.

Diagrammatic Section of the Old Seabeaches Valley of the Barrow.



A. B. C.—*Ancient Marginal Cliffs.*

a. b. c.—Meteoric talii due to the weathering of the Old Cliffs.

e. f. g.—Meteoric Slopes.

* This drift, as also that over the limekiln, contains ice-dressed fra some of hard grit retaining the old polish and etching. One of th cates for the "upper glacial drift" in Ireland, previous to being poi the limekiln, said that the drift over it was "undoubtedly glacial dri

The accompanying diagrammatic section represents the 25 feet, the 100 feet, and 300 feet seas terraces in the Valley of the Barrow, the distances between the different terraces being curtailed to allow them to fit into our diagram—the dotted lines representing the cliffs prior to their being weathered. The character of the talus on the *300 feet terrace is to be excessively similar to glacial drift, it being the *debris* of glacial drift; while those over the 100 and 25 feet terraces, are more or less a mixture of the *debris* of glacial drift and estuarine gravels, as usually the upper portion of the cliffs from which they were formed, is gravel. The meteoric drift in both of these slopes contains a large percentage of icc-dressed fragments, often polished and etched, and many observers have classed them as glacial drift. The depth of these meteoric drifts vary, their maximum depth being generally about half the height of the original cliffs. Such meteoric drifts capping gravels, have been called in many places of late years "upper glacial drift," and from such date we are asked to believe the existence of a second glacial period.

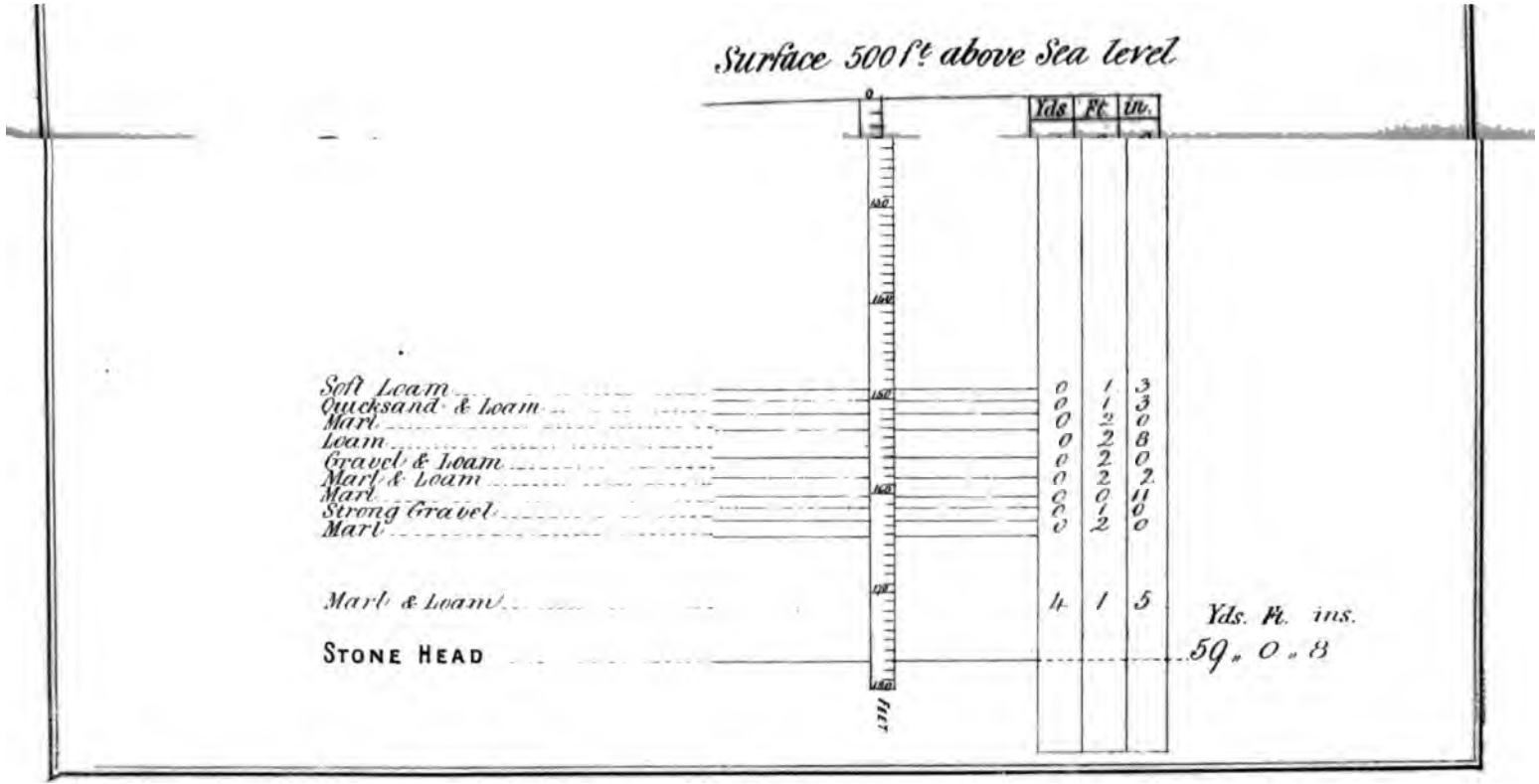
The *Æolian drift* is conspicuous in places. We cannot point to any undoubted pre-or-intra-glacial accumulations, but those of post-glacial age are well represented. In places at the margin of the "Esker Sea," such as on the Cratloe hills, County Clare, north of the estuary of the Shannon, there are great tracts of fine sand, locally called "rabbit sand," also in places at the margin of the 100 feet sea, as at Birdhill, County Tipperary. These accumulations usually are found at or near the inver or mouth of a valley down which a glacial river probably flowed; we may, therefore, suppose that the sand was formed in glaciers, similar to what is going on at the pre-

* The height given are the average height, as the terraces rise in height slightly as we proceed up the estuary.

sent day, while subsequently, after it had reached the sea shore, it was blown up into hills by æolian action. In other places, such as in the Esker at high levels, and at the previously mentioned "heads of the tide," the sands seem to have been brought to or near their present positions by tidal action, and afterwards to have been drifted by wind. All these æolian accumulations are now clothed with vegetation, as are also some of those that were formed at the margin of the 25 feet sea; but many of the latter, and most of those belonging to more recent times, are still shifted hither and thither by the wind. Those at present forming are of two distinct kinds—silicious and calcareous, or *shell sand*. On the East and South-East coasts they are nearly altogether silicious; and are very prevalent in places forming bars enclosing lagoons, in others filling up bays that were formed when the sea was at about the 10 feet contour line. On the West coast much of this drift is calcareous, at the mouth of Galway Bay containing more than 75 per cent. of limey matter. Along this coast, as the prevailing winds are from the westward, it is usually piled up at the heads of the bays or on a low coast line, backed by high land. In some places it occurs as "sand streams." In South-West Mayo the inhabitants near the shore have great difficulty in keeping the sand from travelling inward and smothering up the arable and pasture land. In the North-West of the same county, adjoining Broadhaven, there were sand hills covered with bent grass; this was burnt off, and the sand began to travel up the hill to the north-eastward. It has gradually crept up about 700 feet, destroying all before it, so that the inhabitants have had to migrate to the other side of the hill. In the vicinity of Galway Bay, on Aranmore, and to the north, in Errismore, the sands within the last forty years have taken to travel southward, and have nearly all disappeared

out to sea; while on the East coast, at Arklow, the great sand duns that once existed have now nearly disappeared.

In concluding this paper I would direct the special attention of members of the Society to the Glacialoid drift, both of marine and meteoric origin; as from what I have seen it would appear to me, that most of the so-called "Upper Glacial Drift" in England, Scotland, and Ireland, are re-arranged drifts, generally either marine or meteoric, and that they are perfectly valueless, as evidences of changes in the climate during the glacial period. In Ireland, I have not been able to find any "Middle Gravels" under an "Upper Glacial Drift," although one of the principal classifiers of the Lancashire drift has said:—"There is as good middle sands and upper glacial drift in Ireland as in Lancashire." In England and Scotland the upper glacial drifts that I have been shown are all very questionable, some being undoubtedly re-arranged drifts. In the latter country, similar to Ulster, I have heard the natives call them "Bastard Till."


Surface 500 ft above Sea level
Yds
Ft.
in.
Soft Loam 0 1 3
Quicksand & Loam 0 1 3
Marl 0 2 0
Loam 0 2 8
Gravel & Loam 0 2 0
Marl & Loam 0 2 2
Marl 0 2 11
Strong Gravel 0 2 0
Marl 0 2 0
Marl & Loam 4 1 5
STONE HEAD
Yds. Ft. ins.
59 " 0 " 8

Surface 500 ft. above Sea level

	Yds.	Ft.	in.
Soft Loam	0	1	3
Quicksand & Loam	0	1	3
Marl	0	2	0
Loam	0	2	8
Gravel & Loam	0	2	0
Marl & Loam	0	2	2
Marl	0	2	1
Strong Gravel	0	2	1
Marl	0	2	0
Marl & Loam	4	1	5

STONE HEAD

Yds. Ft. ins.
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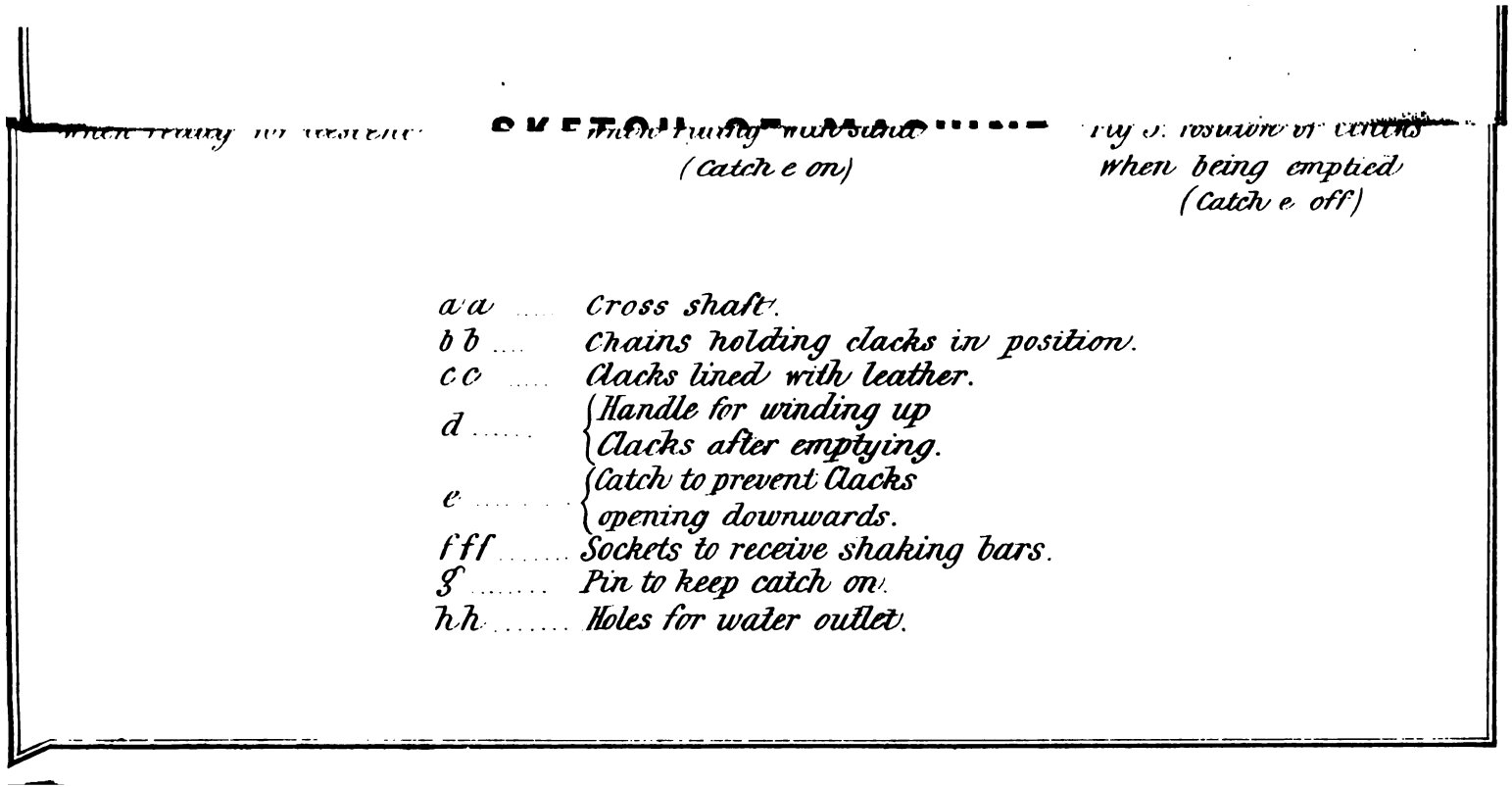


a a	Cross shaft.
b b	Chains holding clacks in position.
c c	Clacks lined with leather.
d	Handle for winding up Clacks after emptying.
e	Catch to prevent Clacks opening downwards.
f f f	Sockets to receive shaking bars.
g	Pin to keep catch on.
h h	Holes for water outlet.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART X. VOL. XIV. SESSION 1876-7.

At the ORDINARY MEETING of the members, held at the House of the Literary and Philosophical Society, George Street, on Tuesday, 27th March, 1877;

Professor W. BOYD DAWKINS, M.A., F.R.S., President, in the Chair.

Mr. James Beswick, Little Hulton; Mr. Henry Taylor Grundy, Radcliffe; Mr. Joseph Grundy, Radcliffe; and Mr. Lees Knowles, Westwood, Pendlebury, were elected ordinary members of the Society.

ON THE VARIATION IN THICKNESS OF THE COALS AND MEASURES OF THE LANCASHIRE COALFIELD.

(Part I.)

BY C. E. DE RANCE, F.G.S.,

Of the Geological Society of England and Wales.

Two years ago it became my duty to commence collecting sections of colliery sinkings in the Flintshire and Denbighshire Coalfields, as a preparatory measure to mapping the geology of that district on the scale of six inches to the mile. Being engaged at the time in the Wigan and St. Helen's

Coalfield, the question of correlation of the Lancashire and North Welsh Measures at once engaged my attention. The problem was evidently one of some difficulty, and of a character only to be solved by the patient accumulation of facts, by an observer in a position to "bide his time," until sufficient light has been brought to bear upon the point at issue. I must, however, fairly confess I have not yet arrived at that position, but propose to lay before this Society the steps by which I hope to secure a successful result.

When first considering this subject, I noticed in comparing some Lancashire colliery sections, that there was a considerable variation in thickness between well-known horizons in different parts of the same field. The question at once arose, can any regular thickening, or thinning of the measures, or coal-seams, be discovered in definite directions, and, if so, do these laws hold good in other coalfields, which have probably formerly been connected with that of Lancashire? To answer these queries I examined the various valuable sections that have been published by the Geological Survey, by Mr. Dickinson, and by others scattered through the transactions of various societies; but unfortunately, few would answer the purpose in hand. They were either general diagrams for a district, or too far from each other, to correlate beds and coals step by step from one pit to another.

I then determined to collect as large a number of colliery journals as possible, in a line crossing the coalfield from S.W. to N.E., or from Prescot to Burnley through Wigan, and Plate 61 of the Vertical Sections of the Geological Survey is the result. It consists of ten columns plotted upwards from the Arley Mine, the lowest coal of the Middle Coal measures as an artificial base line, the well-marked character and constancy of this seam rendering it peculiarly valuable for this purpose. The varying heights of the

columns represents the different depths of the individual pits described, which have been chosen as far as possible as equal distances from each other, with the exception of the tenth column representing the Burnley section, which coal-field has been separated from that of Wigan by a subsequent upheaval of Millstone grits, bounded by faults, forming the district of Anglesark Moors.

For the purpose of comparison, I have found it convenient to divide the Middle Coal measures of the Wigan area into the following groups, for the purpose of comparing them with the area on either side, in descending order :—

F. *The Ince group*, from the Ince Yard coal to the Pemberton 5 feet.
E. *The Pemberton group*, from the P 5 feet coal to the Wigan 5 ft.
D. *The Wigan group*, from the W 5 feet coal to the Wigan 9 feet.
C. *Cannel and King group*, from the W 9 feet coal to the Yard coal.
B. *Bone Coal group*, from the Yard coal to the Orrel 5 feet.
A. *Orrel group*, from the Orrel 5 feet coal to the Orrel 4 feet or Arley Mine.

In tracing these groups across the district to the N.E., group A, will be seen to be very constant in thickness, the movement of subidence at this era being equal throughout the whole area.

Group B is more developed in column II., (St. Helens) the distance between the Orrel 5ft. and the Whiston Main, or Roger coal, (the equivalent of the Yard Mine), being greater there than anywhere else, in other words, a special line of subsidence, or a contemporaneous synclinal axis had come into being, and ranged through what is now St. Helens. It would be tedious to follow the movement of this axis through all the various belts, but suffice it to say that it gradually travelled north-eastwards in time, until in the Ince coal era, the group F, it was situated in the district of Worthington, near Wigan, where the distance from the Ince Yard coal to the Arley Mine is 2200 feet, in column VIII., while at Prescot it is only 1400 feet, the measures having thickened

50 feet per mile, for each mile traversed through a horizontal distance of 16 miles; this thickening in the first four miles is at a rate of no less than 82 feet per mile, and of 60 feet per mile for the next five between columns III. and IV., the average of 50 feet being produced by the last six miles, increasing only at a rate of 20 feet per mile.

At Burnley, on the other side of the basin, the measures between the same horizons are only 850 feet in thickness, the average thickening from Burnley towards Wigan being at a rate of 64 feet per mile, for each of the 21 miles of distance between these points; whether this rapid dip flattens towards the centre of the basin, as it does on the other side, it is impossible to tell owing to the roll of older rocks brought up by later faults intervening between the Burnley and Wigan basin before alluded to. From these facts, no one can, I think, doubt that in the Wigan coal-field we have a striking example of the formation of a contemporaneous synclinal, in which, deposit kept pace with the downward movement, so that the pauses in the movement are marked by contemporaneous coal seams extending over nearly the whole area. These, however, are occasionally absent, as the Pemberton 5 feet at Park Lane, and are often of varying thickness, and sometimes only represented by under-clays—the isolated presence of which, without the neighbouring column, where the clay is seen associated with its overlying coal-seam, would be somewhat puzzling. Again, occasionally seams of *Anthracosiæ* shells, locally called "cockle-shells" by the colliers, associated with bass, followed across country become well-marked coal-seams, connected with cockle-shell bands; thus the Bone coal of Wigan traced to the S.W. becomes the Cockle-shell Bass found above the Orrel five-feet coal of St. Helens, while the well-known *Anthracosia robusta* seen lying beneath that seam at Wigan, is represented by a six-inch coal at St. Helens; in the latter district the peculiarly

hard rag known as the "Burr," or Scotchman, lying between the Orrel five-feet mine and the lower Anthracosian seam, in Wigan appears to be absent.

In the Bradley Halls, column VII., a band of dark gritty *limestone* occurs between the Raven coal and the Yard coal. which is interesting as foreshadowing the conditions which prevailed in the succeeding Upper Coal Measure period.

It might, perhaps, have been expected that the greatest thickness of coal, would have been found in the centre of the basin, but such is not the case, though perhaps the quality is better there than anywhere else. The thicknesses are as follows:—

In Column I.	94·7	feet in	19	seams,	15	being above 2 feet	
,, IV.	84·7	,,	35	,,	13	,,	,,
,, VII.	79·5	,,	27	,,	15	,,	,,
,, X.	52·7	,,	19	,,	14	,,	,,

For comparison with this table I may give the thickness of sandstone in the same columns:—

In Column I.	320	feet, or	$\frac{1}{4\cdot6}$	of the whole vertical distance.	
,, IV.	760	,,	$\frac{1}{2\cdot6}$	,,	,,
,, VII.	370	,,	$\frac{1}{5\cdot8}$	,,	,,
,, X.	250	,,	$\frac{1}{5\cdot4}$	,,	,,

It will be noticed that the gradual change of thickness observable in the coal seams may be represented diagramatically by a wedge, of which the thick end rests on Prescot, and the thin end on Burnley. It will also be observed that the coal seams have a tendency to run together at the edges of the basin, and to split up towards the centre, where the coals are wider apart, and separated from each by thicker sedimentary deposits, precisely in the same manner as the thick coal of Staffordshire, splits up into a numerous series, ranging through a considerable vertical space, when traced through a few miles of horizontal distance, a fact which led the late Professor Beete Jukes to

consider that all thick coal-seams are in reality a succession of seams, accidentally lying the one over the other, through failure of sedimentary material or other causes in the periods intervening between the formation of each.

As shingle and sand is generally thrown down in irregular banks near a coast line, its weight preventing it being held in mechanical suspension in water, and carried away by currents, it might be expected to be found poorly represented in the centre of the Wigan basin, into which the lighter mud forming the shale of the coal measures would be carried. This is precisely so, the sandstone in the centre of the basin, only form $\frac{1}{8}$th of the entire mass, while at the edges, they constitute $\frac{1}{4}$th and $\frac{1}{3}$rd respectively.

In these results, we have two facts, which are useful for correlating purposes in North Wales, the south-westerly attenuation of sedimentary matter, and the thickening of the aggregate coal-seams in the same direction. The results of the Welsh sections, that have now been plotted, forming two plates of sections prove these conditions to hold good, but the sections not having yet been published by the Geological Survey, I am prevented giving any details at present, though I may, perhaps, state that we have reached the thicker end of the coal wedge, in the neighbourhood of Ruabon, from which the coal appears to thin away in the opposite direction.

My colleague, Mr. Topley, in a paper* read at the Geological Society of London, "On Areas of Apparent Upheaval," states that the high dip around most basins is due not merely to upheaval but to a thinning towards the dip of the subjacent strata, which thicken towards the rise, while as regards the strata that form the basins themselves, the converse is the case, for they thicken towards the centre of the basin. And he cites as instances the strata of the Newcastle Coalfield, which

* Quar. Jour. Geol. Soc., 1874, p. 186.

thicken towards the centre of the basin, the seams of coal being wider apart than along the western margin, and the easterly dip being greater in the lower seams than in the upper, which dip is clearly the result of unequal deposition, and not of subsequent undulations in the strata.

Professor Hébert states that the Tertiary rocks of the Paris basin thicken towards the centre, whilst the underlying Lower Cretaceous rocks thicken as they rise to the west. Mr. Topley states the same phenomenon to occur in the London and Hampshire tertiary basins.

Mr. Topley points out that the dip of the Great Oolite, beween Leekhampton Hill in the Cotteswolds and Burford to the east, a distance of 19 miles, is 600 feet, which is entirely produced by the attenuation of the strata in that direction, to that amount.

Similarly the thickness of the New Red Sandstone is given by Professor Hull, as 5,600 feet in Cheshire, and about 600 in East Warwickshire, so that in 80 miles it has thinned 5000 feet, or about 62 feet per mile. And should these rocks have happened to have been covered with later strata, they would of necessity have been subject to a dip of that amount due to this cause alone, and not to any subsequent movement of the earth's crust.

Another remarkable instance of rapid thinning is given by Mr. Topley, viz., that of the Millstone Grits west of Sheffield, which thin from 3,500 feet to 1,500 at Belper, a distance of 20 miles, which is equal to a dip of 1°. If these Millstone Grits had been entirely covered up with Coal Measures, this dip would certainly have been attributed upheaval or depression.

From these facts it would appear to be certain that any observed dip holding good over considerable areas, in a special direction, is not necessarily entirely due to any subsequent movement of the earth's crust, but may have been

formed by contemporaneous deposition on a subsiding inclined plane, produced by the unequal deposition of the proceeding strata.

Professor Phillips, in his Geology of Yorkshire, commenting on the purity of the argillaceous deposits on the west, and of the gritstones to the north, suggested the entrance of two primeval rivers, or currents, the one from the west bearing sediment from an area composed of argillaceous slate, the other from the north, bringing the granular detritus of regions occupied by gneiss and mica slate. This classification, though holding good for nearly the whole of the carboniferous rocks of Yorkshire, in Lancashire does not appear to have come into force until the Middle Coal Measure period in which sandstones are strongly developed in Yorkshire, individual beds ranging over considerable areas, so that each bed may be separately mapped as has been done on the maps of the Geological Survey, which would be absolutely impossible to carry out in the Lancashire coal-field, where sandstones and grit-beds are unimportant, uncertain, and of no great horizontal continuity.

The Millstone Grit, on the other hand, attains its maximum thickness in the British Isles in Lancashire, being no less, according to my colleague Mr. Tiddeman,* than 5,500 feet at Sabden, near Burnley, diminishing, according to Messrs. Hull and Green, to 2,500 at Mottram, a distance of 30 miles, or 100 feet per mile, to 500 feet in North Staffordshire, and to 50 feet in Leicestershire, or 5450 feet in 80 miles in a S.S. Easterly direction, or 68 feet per mile. From these facts it would appear that the westerly river, or current, bearing clayey matter, and the northerly river, or

* Quoted by Professor Hull, F.R.S., in his paper "On the Thickness of the Carboniferous Rocks of the Pendle Range of Hills, Lancashire," as illustrating the author's views regarding the "South-easteriy attenuation of the Carboniferous Sedimentary Strata of the North of England."—Quar. Jour. Geol. Soc., 1868, p. 319.

current, bearing sandy matter, were contemporaneous in the Coal-measure period of Lancashire and Yorkshire. In the previous Millstone-grit era, this was not the case, and the river, or current, flowing from the north alone existed, bringing more material to what is now the western side of England than the eastern, and depositing a less and less amount of detritus as it flowed southwards; a striking instance of which is seen in the First Grit, or Rough Rock, of Hoghton Tower, which attains a thickness of 400 feet, while at Parbold Hill, only 11 miles to the south, it is only 100 feet, having thinned out no less than 30 feet per mile, on the strike, equal to a dip of 1 in 176, on which inclined surface the Lancashire Coal-field is deposited.

When comparing adjacent colliery sections, separated from each other by a fault, I have noticed a difference in the vertical thickness between two given horizons. In many cases this is doubtless due to difference of the amount of dip on the opposite sides of the fault, but occasionally the phenomenon is observable when the dip is the same. In these cases I believe it to have been produced by horizontal shifting along the lines of fault, which have brought a slice of Coal-measures originally deposited at a greater distance from the centre of the basin, and therefore *thinner*, against another slice, formed in the thicker portion, nearer the centre. That horizontal shifting takes place in faulted mineral veins, I am tolerably certain, from the direction of the Slickensides, preserved in pyrites, on their faces, and from other facts.

The researches of Mr. J. M. Wilson, M.A.,* render it tolerably certain that contortions in strata are the inevitable result of the subsidence of a curved surface, and that faults are cracks, the result of the re-elevation of that curved surface, in which "the rocks have to expand, so as to fill a larger area."

* *Geol. Mag.*, 1868, p. 333.

From the presence of the Permian rocks, on various portions, not only of the coal measure series but of the underlying Millstone Grits, it is certain that these formations had already obtained their dip, being subjected to lateral pressure, which had squeezed and forced up into a series of sharp anticlinal rolls, the older underlying strata, phenomena produced by the movement of subsidence taking place at the close of the Carboniferous period, which subsidence was followed by much contemporaneous marine denudation which wore the surface of the various Carboniferous series into a plain of marine denudation, on which was afterwards deposited the Permian rocks. This denudation not only affected the Carboniferous strata of the North-West of England, but the Lower Silurian tracts of West Cumberland, where the Permian strata rests transgressively on the eroded Coal Measures, Mountain Limestone, Green Slates, and Porphyries, and Skiddaw slate.* The great synclinal and anticlinal folds, ranging E.N.E., which formed the northern limits of the Lancashire and Yorkshire Coalfields, and plicated the Millstone Grit and Yoredale Hills of the Pendle Range, and brought into existence the Mendip and Ardennes Anticlinals, came into being after the deposition of the Lancashire Upper Coal Measures, and before the era of this extensive marine denudation. From my examination of the rocks of the North of England, I agree with the conclusion of Professor Hull, that the second system of disturbance, ranging about north and south, was an upheaval producing faults, the most important of which, the Pennine anticlinal, dissevered the Lancashire and Yorkshire Coalfields at the close of the Permian era, which was followed by a second period of upheaval fracture, ranging about N.N.W., after the deposition of the Oolites.

* For details of these movements see Professor Hull's paper "On the Relative Ages of the Leading Physical Features and Lines of Elevation of the Carboniferous District of Lancashire and Yorkshire. Q. J. G. S., 1868, p. 323.

These faults have an important bearing on the Wigan coalfield, dividing it into a series of watertight compartments, at nearly equal distances of 1400 yards apart. Some of the chief are the—

1. Great Pemberton fault, downthrow E. .... 470 yards.
2. „ Shevington „ „ .... 600 „
   (which brings in the W.S.W., or Pemberton dip).
3. Great Standish fault, downthrow E. ..... 160 yards.
4. Giants Hall fault of Ince, downthrow W.. 600 „
5. Great Haigh fault, downthrow W. ..... 600 „

It is worthy of note that the abnormal dip in the West Lancashire coalfield, brought in by certain faults and called "Pemberton dip," is similar to that immediately west of the Pennine anticlinal fault; or, in other words, the normal Wigan dip E.N.E. is in no way affected by that fault, its influence being lost a few miles from the anticlinal.

Notwithstanding the enormous thickness of the Millstone Grit in Lancashire, the presence of thin coal seams throughout the whole series, and of fragments of coal plants in the midst of the thickest sandstone, would point to a sea of no great depth, in which, from time to time, the sea-bottom was either elevated, so as to become a land surface, above the level of the sea, or else the sea was kept out, by the formation of barriers of sand and mud, at the entrance of inlets, behind which plants grew at elevations, actually a few feet below that of the sea outside. The sea never attaining any great depth, the amount of deposition about keeping pace with the rate of subsidence, so that the depth remained the same, and the same marine organisms found fossil in the shales were enabled to live on through the whole period, and in fact are found present in the shales of the Gannister Beds or Lower Coal Measures. In the succeeding Middle Coal Measure era, these pauses in subsidence appear to have lasted longer, plant growth succeeded plant growth, and thicker

coal-seams were the result, fresh water condition were more prevalent, though I think it probable that the fish, whose remains are so prevalent in some of the shales overlaying the coal, and in fact in the cannel coal itself, were capable of living in sea water, as is the salmon at the present day, and though we find the same species of fish at successive horizons, probably of fresh water origin, it was in an outer area of salt water that the species lived on in the meanwhile. The researches of Mr. E. W. Binney, F.R.S., and others have shown that the Cannel coal of Wigan is composed of excessively comminuted vegetable matter, and that spores of Lycopodiaceous plants are common in it, which would not have been floated far, which is extremely interesting when it is remembered that this is precisely the area where the action of subsidence during the Middle Coal-measures was greatest.

Conclusions.—It would appear probable from the observed facts, that the Lancashire and North Flintshire coalfields were deposited over an inclined plain of Millstone Grit, sloping to the southwards.

2. That in Middle Coal-measures times a synclinal axis came into existence, causing a greater depression of the coal basin along a definite line, which gradually travelled to the north-east in time, until it reached Worthington, near Wigan.

3. That the deposition of the Coal-measures was followed by continued subsidence, which caused the carboniferous series, and the underlying older rocks to be rolled into a series of flexures, before the denudation, which preceded the Permian epoch.

4. That after that era, an upheaval took place, which produced lines of fault, ranging N. and S., which was followed by another upheaval, along N.N. westerly lines.

I would wish to take this opportunity of thanking the numerous colliery proprietors, who have so freely given me

assistance, and without whose aid, my results would have been absolutely unattainable. Where so many have helped it is almost invidious to mention names, but I may say I am specially beholden for information to Mr. John Smethurst, of Wigan; Mr. Watkin, of Pemberton; Mr. J. Thompson, F.G.S., of Norley; Mr. C. Clark, of Park Lane, Ashton; Mr. W. Smethurst, F.G.S., of Bryn; Mr. Ffrance, of St. Helens, and to my colleague Mr. Strahan, B.A., F.G.S., for assistance in carrying on the work in every way.

Mr. Dickinson said he observed that Mr. De Rance gave the authorities for the sections which illustrated his paper. Who, he would like to ask was the author of the Burnley section? Some years ago, when he (Mr. Dickinson) brought a paper before the Society, which appeared in the transactions, he gave the names of all the authorities to whom he was indebted for sections, and, amongst others was the name of Mr. George Wild, a colliery manager, now present. Mr. Wild was the author of the Fulledge section at Burnley. If the same section had been adopted by Mr. De Rance in his chart, he might say, from experience which had been gained since, that one of the coal seams which Mr. Wild then identified had been proved not to be the coal he (Mr. Wild) took it for, and that there was a greater thickness between the King Coal and the Arley than was supposed at the time in question. The connection was then traced through a fault, not by direct sinking; and that might explain some of the difference in the thinning which Mr. De Rance had shown between the south-western and north-eastern parts of the Coalfield.

Mr. De Rance said he found at the head of the No. 10, Burnley column, referred to by Mr. Dickenson,—"Fulledge Colliery and Cliviger Colliery, Reduced from Vertical Sections of the Geological Survey, sheet 33, Nos. 8, 9." The upper

portion of the section is from the Fulledge Colliery, and the lower from the Cliviger Colliery. He had not put the authority of gentlemen's names from whom his colleague, Professor Hull, got his information, but he had no doubt whatever that, when the plate sheet 33, was referred to, the names of those who supplied the two colliery sections would be found to be stated. Doubtless Professor Hull got his information at the collieries: he (Mr. De Rance) did not think he would take it from the transactions of any scientific society.

Further discussion upon the paper was adjourned to a future meeting.

ON UNDERGROUND FIRES.

By W. J. Grimshaw, F.G.S.

Great effects are often produced by small causes, and from that point of view fires occurring above ground or below ground are mu h alike. An unforseen occurrence or careless act, which causes a fire above ground, may in a similar manner cause one underground, but as regards after results all similitude ceases. As instances, the writer may mention that fires of more or less magnitude have come under his notice, resulting from the following causes:—

1. Ignition of canvas air tubing from a small feeder of gas which was lighted by a shot. The men left the place and gave no alarm for some time afterwards. This fire gained great headway, and after several violent explosions the pits were sealed. On re-opening, about two months afterwards, a violent explosion occurred, and the fire was eventually subdued by flooding the pits.

2. Shots fired at the end of a shift, and places not examined for some time after.

3. Torch lamp falling into an open grease box near pit bottom.

4. Furnace ashes filled into a tub without being properly slacked.

5. Shot bringing coal down solid, and igniting gas in break behind.

6. Soot clogged on curbs and sides of a furnace pit by accidental influx of water. Fired two days after.

7. Backing on arching igniting spontaneously.

8. Mouthing 14 yards above furnace catching fire from furnace.

9. Timber behind pit walling, opposite furnace, drift ignited from furnace.

10. Spontaneous combustion, and burning through or displacement of rib or barrier left to cut off a gob fire.

In the course of conversation with Mr. J. S. Martin on this subject, he mentioned the occurrence of two fires at the Hibernia Colliery, Westphalia, one of which was caused by the ignition of a small quantity of gas in an old road, and the flame withdrawing behind a pack, burned so long as to ignite some old timber which had been stowed there. The other was caused by a torch lamp, placed behind a prop to shield it from the air, igniting the timber. This occurred in a main return airway through which steam pipes were carried, and the fire extended a distance of about 140 yards in less than six hours.

The above tabulation of a few of the causes of underground fires may give some idea of the difficulty of taking any other than general precautions to guard against their occurrence. Comparatively speaking, a fire on the surface comes to a definite end, in a reasonably definite time—the progress thereof may be marked without risk, and the best means of dealing with it are generally obvious. Many causes, however, conspire to render the extinction of an

underground fire a much more arduous and dangerous undertaking, whatever means of dealing with it may be adopted.

Broadly speaking, but four courses are open for choice, viz:—

Following the fire up, and extinguishing it with water.

Flooding the mines wholly or partially.

Sealing the shafts, the workings, or part of them.

Filling the mine with carbonic acid.

As regards the first mentioned course, an interesting paper was read before this Society by John Knowles, Esq., detailing the process as applied to a fire at Pendlebury Colliery, which was eventually extinguished by this means. Proverbial wisdom says that "delays are dangerous," and in no case is the maxim more pregnantly true than in relation to dealing with fires in collieries. An hour of active measures at the commencement is often more valuable than months would afterwards be; and, in addition, the writer believes that, generally, the earlier a fire is dealt with the safer it is for those engaged in the operation. Following up the fire with water is certainly the most satisfactory method of dealing with it; the progress that is being made is known, there is greater scope for the exercise of judgment, and greater sense of security than there is for those employed in building off a fire. In fact, the difference between the two methods may be likened to the difference between fighting a duel in open air and in a dark room.

Another strong reason in favour of following up with water is that when the fire is subdued, work may be resumed in a very short time in the majority of cases. The fire is done with, and the great expense of keeping the pit idle for an uncertain period is saved.

Considering this method of battling the fire the best, yet the writer does not mean to assert that it ought to, or even

could, be tried in all cases. The varying conditions of different mines, and the constantly varying conditions of any one mine, preclude any special provision being made to deal with a fire, wheresoever it occurs, by any special means. Consequently very much depends on individual effort called into action by the emergency. It has been said that the "unexpected always happens," but unfortunately few people are gifted with the power of defining the "unexpected."

Even when means of dealing with fire are immediately at hand, it does not seem that success is always achieved.

In the "Report of the Department of Mining, Nova "Scotia, for the year 1873," will be found an account of a fire at the Drummond Colliery, in Pictou County, belonging to the Intercolonial Colliery Company.

A portion of the evidence of the hewer, Robert Mc.Leod, in whose working place the fire originated, is given as follows :—

"I went to work on the morning of the 13th May in the "main level, No. 2 slope. I found 6ft. of gas, and that on "the high side. During the morning I fired two shots in "the fall, and neither set fire to the gas. About a quarter "to twelve I fired a shot in the bench on the low side. It "did not blow well, and the gas caught fire. We battled "with the fire for about fifteen minutes, and had then to "retire for fresh air. When we endeavoured to return we "could not for the smoke. We went in by way of the "lodgement, and found the fire had caught the brattice.

"Had I been able to shovel the coal from the face I could "easily have put out the fire.

"There was less water than usual in the barrels, but I "have little doubt that the barrels would have been filled in "the course of the day.

"Before I left the level the first time the smoke was "backing down against the air."

Another witness says:—

"Before twelve o'clock I got word that Mc.Leod's level "was on fire. I went at once to the face, and helped to "work at the fire by throwing water and beating at the "flame with wet bags, but we could do little, as the smoke "soon sickened us."

Mc.Leod's loader says:—

"There were two barrels of water not far from the face, "one full and the other half full; there was also a sump "with plenty of water about 100 yards from the face."

John Lorimer, a hewer, says:—

"There was always plenty of water and appliances for "putting out fires."

Under the Mines Regulation Act, 1872, a fire from a similar cause is hardly likely to happen here, but the cause is immaterial. What the writer wishes to draw attention to. is the proximity of means for dealing with the fire, which were promptly applied, yet were ineffectual, for owing to derangement of the ventilation, explosions took place by which 59 lives were lost. Water was turned into the pits, but for 36 hours the flames shot up to a height of 30 to 40 feet at openings on the crop of the mine. A Mines Act has come into force since this accident, which more nearly assimilates the conditions of working to those obtaining in this country.

If the course chosen needs the sealing of the shafts or the airways, many circumstances require to be taken into consideration. It may so happen that it is impossible to stop the return on account of the smoke, &c., coming from the fire. Then the need of deadening the fire is obvious, and the most expeditious way of so doing is to arrest the air which is feeding the flame by stopping up the intake. When that is done, the course of events may be as well observed on the surface as underground, and more safely.

In 24 to 48 hours, if no explosion has occurred, an attempt may be made to put a stopping in the return. If any difficulty is experienced, owing to the noxious fumes or gas, the air at command may be used to keep the place sufficiently clear for the time required for building the stopping. A pipe, with a valve, self-acting outwards, is sometimes inserted in one of the stoppings, with the object of relieving any pressure that may accumulate in the barred-off district.

When a fire is sealed, if the discharge of gas continues whilst the fire is burning, the gas and the oxygen of the air will combine, and hereby a vacuum will be formed through the combination of the gases, as one volume of carburetted hydrogen and two volumes of oxygen combine to one volume of carbonic acid.

If air is then let in, the fire will be fed. It seems to be hardly desirable to open the stoppings till there is neither suction or discharge.

It is a point worthy of consideration as to whether a stopping need be put in the return when the fire is built off.

An account of a fire, which incidentally bears on some of the above-mentioned points, may not be without interest.

The section of the mine in which the fire occurred was:—

	Ft.	In.		Ft.	In.
Ragman Coal	4	0		....	
Strong Bass	....			6	0
Seven Feet Coal	7	0		....	
Yardley—Inferior Coal and Pyrites	....			0	10
Holing Dirt	....			1	3
Hams or Rough, 5ft. coal ..	5	6		....	
Total coal.....	16	6	Dirt	8	1

And the roads were partly driven in the 7ft. and partly in the Hams Coal. Sometime on Sunday evening the rib at A *(see*

sketch) must have given way, bringing fire down from the old works above. Two firemen descended the upcast shortly after twelve on the Sunday night, and one was rendered insensible, and the other nearly so, by the noxious fumes from the fire. The fire gained great headway, and between two and three o'clock two slight explosions occurred. As it was deemed hopeless to attempt to extinguish the fire, and fears were entertained that it might reach the upcast pit, it was determined to close the intake airways. Accordingly the stoppings 1 and 2 were put in, and all hands cleared out of the pit. The dense volumes of black smoke issuing at this time from the upcast pit gradually lessened, and the colour became much lighter. The stoppings were examined three or four times during the day. Next day the discharge at the upcast had changed its colour to a misty white, which gradually decreased in density. Stoppings 3 and 5 were put in, and many attempts were made to put a stopping in the S. return airway, but the fire-stink was so strong that it could not be done. The stopping in the north intake was then taken out, and the air worked round for some time. It was by means of brattice turned past the mouthing by which it returned into the upcast pit, and the men were enabled to put a series of substantial stoppings in the return. All weak places were then made good, and work was resumed at the pit, it being considered safe.

In this case, although the fire was situate in the extreme rise of the workings, "fire-stink" could be perceived at the low side of the stopping 6, from which fact the writer draws the inference that in this case a considerable portion of the south side workings was filled with it, as it had no means of reaching that point except through the leakage or disturbance of a door or stoppings. The south side workings were not re-opened, as the coal had been worked to within a short distance of the limit of the shaft pillar. The writer

does not suppose that the fire on the south side workings was extinguished, though the means adopted proved adequate to enable the north side of this mine and the other mines to be worked safely.

Water is seldom of use in dealing with a "gob fire," indeed the position and extent of such a fire generally prohibits the efficacious use of it. In the majority of cases a peculiar smell gives a timely warning of the heating of the gob, or if the gob is actually on fire in some remote portion of the old workings, the smoke generally makes an appearance before there is much danger of actual fire reaching the workings in progress. In mines where gob fires are prevalent, sometimes the coal is worked in districts, with ribs or barriers left between each; and when a district is worked out, substantial stoppings are put in the roads communicating with such districts, 10 yards long. This practice necessitates the loss of much coal. This has been notably the case in the thick coal of South Staffordshire.

Sometimes the coal is worked from the extremities, and if the gob fires, a breadth of coal is abandoned, and strong stoppings are put in the roads driven through the barriers.

A goaf generally contains more or less fire-damp, kept in its situation by the air sweeping the edges. When the barred off portion of a mine contains goaf, it is probable that the gas released from the goaf may form, with the air and the products of the combustion, a mixture that will not explode. The fire feeding on the oxygen of the air is lessening the supply continually, so in all probability the more gas there is released in a body from the goaf the less is the danger of explosion.

Much doubtless depends on the state of the workings when it is determined to bar-off a standing fire. If fire-damp is known to be standing in the workings, it requires to be kept as pure as possible.

When the writer was in Staffordshire, it was a common saying that if a mine did not fire within two hours after being sealed it was safe. Without going so far, the writer must say that in several instances which have come under his observation an explosion has taken place within that period. Why and wherefore he is unable to say. The diffusion of gases has doubtless something to do with the matter; but a mine is not like a laboratory, and with all judgment attainable, assisted by experience, sealing up a mine must of necessity partake somewhat of the nature of "a leap in the dark."

Mr. Buddle, in his evidence before a Parliamentary Commission in 1835, gives an account of gas, which was lighted in a partially stored bord at Wallsend Colliery, being extinguished by the concussion produced by firing a fast shot, drilled into the roof near the entrance. He also mentions providing small cannons for use in similar cases; and the writer has heard of similar provision at a Lancashire colliery in bygone days.

Sometimes a fire occurs which it is impossible to approach sufficiently near to reach with water, or in some cases to judge of its extent. In others it is even impossible to ascertain the locality. Then but two courses are immediately open—one being the flooding of the mine, the other stopping the air, either by sealing the shafts or the airways. The first method is highly undesirable if the workings are situate on the rise of the shaft, and have no level communication therewith from their highest point. A case came under the writer's notice some years ago, when the mine was flooded to extinguish a fire on the rise. The water rose in the shafts to a point very considerably above the level of the extreme rise workings, and was allowed to remain in for seven weeks. Several "water blasts" occurred in course of winding it out, and on exploration of the mine it was found

that the fire was still burning, the water never having reached it. The reason for this was obvious—the air being compressed to such an extent as to resist the weight of water and allow it to rise in the shafts.

Flooding a mine generally brings down the roof and causes the floor to swell, often to such an extent that it is found better to drive new roads than attempt to re-open the old. This is more especially the case where the inclination of the strata is steep; and the expedient is hardly one to be adopted on a large scale, unless circumstances render other means impracticable or unadvisable.

The writer has not seen the application of carbonic acid to extinguish underground fires, but doubtless some gentlemen here present have. In the minutes of evidence before the Select Committee on the Prevention of Accidents in Coal Mines, June, 1849, will be found some valuable and interesting evidence respecting this method, chiefly given by Mr. Goldsworthy Gurney.

Whatever means are adopted in dealing with underground fire, it is not desirable to have in the pit more men than are strictly necessary for conducting the operations.

On the occurrence of a fire, if no means of extinction are immediately available, it may sometimes be advisable to lessen its intensity by closing some of the approaches to it by means of brattice or other available materials.

Underground fires travel against the air, and in some cases it might be good policy to "draw" the fire by turning a quantity of air through it.

Sulphur is a very effectual extinguisher, and might possibly be of use thrown into a fire, due care being taken to have no one in the return airways.

But let all the precautions be taken that human foresight can devise, fires will still occur, and after all, the chief remedy is promptitude in dealing with them. A mine is

not like a workshop, where the overlooker may go from room to room, and see the workmen at a glance; and this difference constitutes a source of extra liability to danger.

Mr. Dickinson said he had assisted in extinguishing many fires in coal mines. They were very disagreeable matters to have in hand; but it was a saying of a former friend of his that a fire in a colliery, now and then, did much good, by giving instruction to men how to treat such difficulties when they arose. Still a fire was one of those things which any mine owner would desire to keep as far off as possible. Mr. Grimshaw's paper was a very practical one, and it was one which would bear reading and studying more perhaps than criticising. There was, however, one point upon which he would like to make an observation; that was with regard to sulphurous acid gas. It was 25 years ago since there was an underground fire in the Great Lever Colliery, near Bolton, belonging to the Earl of Bradford. Mr. Gurney was sent for, and he came and applied his apparatus, first with a coke fire to produce carbonic acid, &c., and afterwards with sulphur and salt, to produce other noxious gases which Mr. Grimshaw had alluded to. But when they came to open out that colliery some weeks afterwards the fire was still found to be burning, and it had eventually to be put out with water. The application of carbonic acid gas—that was the forcing in of a current of carbonic acid or any other gas—was, according to his (Mr. Dickinson's) experience, rather injurious than otherwise, because the current it created carried some air with it, which tended to fan the flames and promote combustion, whilst a quiet atmosphere, shut off, had the reverse effect. He had been reminded that limestone was also put into the fire with the salt and sulphur at the Great Lever Colliery, but without effect.

Mr. GRIMSHAW said he had not seen Mr. Goldsworthy Gurney's system tried, but from what he could gather from the accounts of it, he should say there was from eight to ten times as much air as carbonic acid sent into the mine by it. Carbonic acid might perhaps be sent down a mine comparatively pure by means of force pumps, or possibly in a solidified form at some future time.

Mr. DICKINSON said there was another point that might be named. It was as to the utility of shutting off the return air course as well as the intake. In his practice he had preferred shutting off both for many reasons—for instance, if a heavy fall of roof took place in the part of the mine shut off, it might have the effect of driving out a large quantity of irrespirable air which might suffocate persons. Another reason was that with increasing atmospheric pressure there was a tendency for air to draw inwards, even with stoppings. Therefore it was better that both intake and return courses should be stopped, leaving, of course, a safety valve to mitigate the pressure, so that the stoppings might not be forced down by the pressure of gas inside, and also for an opening to test by.

Mr. THOMPSON said in the case of a fire with which he had to do, and on which he read a short paper before the Society, he made observations three times daily for months through such a valve as Mr. Grimshaw had described. The registered temperature was 78°, but when they got into the mine he took observations up to 94° within twelve yards of the point where 78° had been registered, clearly showing that slinging a thermometer opposite the mouthing of a mine on fire gave results that were practically valueless.

Mr. DICKINSON said that when a mine was built off they had only a limited number of ways of judging whether the fire was out or not. Temperature might not be an infallible guide, but if, having shut a mine off, they found the temperature

registering say 100°, and that gradually declining until it reached the natural temperature of the mine, it was some guide to go by. They might also judge somewhat by the smell, and by the purity of the gas that came off. There was generally a peculiar stink in the gas that came from a mine on fire, and the fire-damp was generally less explosive when mixed with the products of combustion. Therefore, when the temperature had gone down, and the outcome was of ordinary smell and in a highly explosive state, they served as guides, but beyond those indications there were few, if any other, things by which to judge.

Mr. SMETHURST pointed out a difficulty in the use of carbonic acid gas for extinguishing fires in thick seams, arising from the immense volume of that gas which was required to displace the atmospheric air. In the mode adopted of shutting off the air in a mine people sometimes made a great mistake. They imagined that they had shut it off, when, in fact, they had done nothing of the sort. It was difficult in a pit to fix a scaffold that would effectually do it. The vacuum caused by the hot air ascending the upcast shaft, and the cool being shut off in the downcast, would have the effect frequently of drawing in the air past the scaffold, or, if the scaffold was tight, of breaking it. The only effectual means of extinguishing fire, as far as he had seen, was by putting in water. He was at Pearson and Knowles's pits when they were on fire. The pits were shut off for a considerable time, and the fire was thought to have been effectually subdued; but when opened an explosion occurred from fire still remaining, and five men were killed.

Mr. H. WOODWARD said he had tried several experiments with the thermometer in a closed mine, such as the reader of the paper had pointed out, and he had found that, while the temperature at the stoppings, which had been in for months, was very low, on entering the closed off part of the

mine, a large fall of roof having occurred at the seat of the fire, no indications of combustion could be perceived, yet when they came to move the dirt they found that the fire was still burning, although the temperature did not increase more than five or six degrees from what it was at the stoppings, 150 yards away. He quite agreed with Mr. Dickinson as to the desirableness of closing both levels—in fact, all communications—for fear of a fall of roof liberating a large volume of gas.

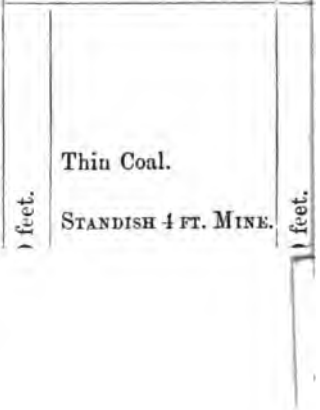
LANCASHIRE COALFI

Sections of the Geological Survey

VII.

BRADLEY HALL,

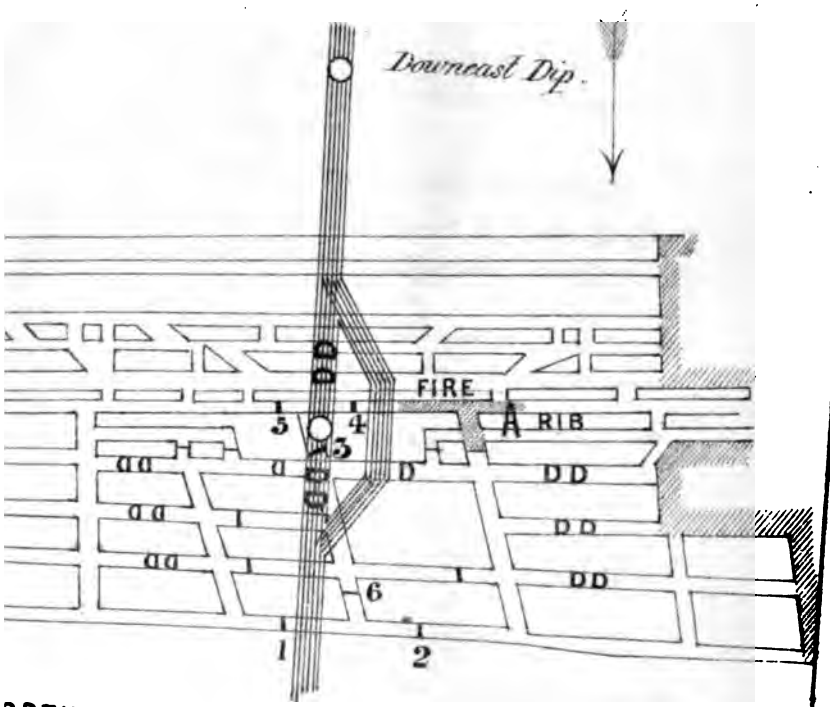
WORTHINGTON.



PLAN OF WORKINGS.

in the Seven Feet Mines, Independent Pit.

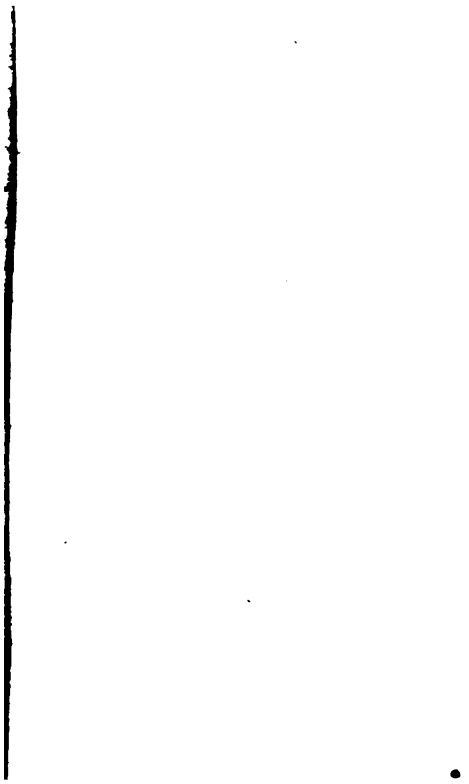
LEYCETT COLLIERY.



ORTH SIDE

SOUTH SIDE

Scale 60 yds to an Inch.



TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XI. VOL. XIV. SESSION 1876-7.

At the ORDINARY MEETING of the Society, held at the House of the Literary and Philosophical Society, George Street, on Tuesday, 24th April, 1877;

Mr. JOHN AITKEN, V.P., F.G.S., in the Chair.

The following gentlemen were elected Ordinary Members of the Society:—Mr. Thomas Edmondson, Cliviger Collieries, near Burnley; Mr. Rooke Pennington, F.G.S., Bolton; Mr. P. W. Pickup, Dunkenhalgh Collieries, Church, near Accrington; Mr. John Waddington, Mining Engineer, Burnley.

The following paper was read:—

ON ROLLED PEBBLES FROM THE BEACH AT DUNBAR.

BY W. J. BLACK, F.R.C.S.E.

Several specimens of rolled pebbles from the beach at Dunbar were exhibited, and the process of formation described of new pebble banks thrown up by the late winter gales, which might be applicable to larger ones elsewhere. At Dunbar, a bank or ridge of the Links on the coast seemed to be the proximate cause of the rising of the stone bank in

front and upon it, as it opposed a breakwater to the landward migration of the stones driven in by the sea waves. Explanations were also entered into to account for the transportation of pebbles up a bank on to its crest, and along its sides, by the difference of the forces of the surge upwards and that of gravitation downwards.

Three typical forms of pebbles were described oblong, flat, and oval ellipsoids, and these shapes were probably due to different amounts of rolling upwards of the surf and sliding downwards of the backwater.

A difference of action was also suggested between waves on pebble beaches and on sandy shores, where the former were shovelled up by the downward plunge of the surf, and the latter levelled down by the return wash from the crest carrying the lighter and smaller particles.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XII. VOL. XIV. SESSION 1876-7.

At the ORDINARY MEETING of the members, held at the House of the Literary and Philosophical Society, George Street, on Tuesday, 29th May, 1877;

Professor W. BOYD DAWKINS, M.A., F.R.S., President, in the Chair.

THE LATE SIR JAMES P. KAY-SHUTTLEWORTH, BART.

The PRESIDENT said: Before we commence the ordinary business, I think that I ought to call the attention of the Society to the death of Sir James P. Kay-Shuttleworth, one of our oldest members. He was a man, as most of us know, of very varied attainments and one who had sympathy with knowledge in whatever shape it presented itself. He was certainly one whom Lancashire could ill afford to spare, for owing to his peculiar position in the world of politics he was a man who always had the opportunity of giving valuable aid to any scientific body that was struggling into existence. From my personal contact with him I would wish to say that, in regard to anything out of the ordinary groove—for example, such a work as the exploration of a Cave, or anything in connection with education, and especially scientific education, Sir James P. Kay-Shuttleworth was a man to whom appeal

was never made in vain without kindly response. I am sure we must all regret the loss the Society has met with by his death.

OLD OAK TREES IN THE BED OF THE IRWELL, AT BROOKSBOTTOMS.

By Rev. Addison Crofton, M.A.

The river Irwell, in its course from Rossendale to Bury, makes several large bends, the space enclosed in which consists of low flat pasture land, and is commonly supposed to occupy the site of an ancient series of lakes. These semicircular pasture lands are called in the neighbourhood "bottoms;" the best known giving its name to the village of Ramsbottom, and another, the next in succession downstream, being styled "Brooksbottoms."

At this latter place stands the village of Summerseat, partly on the low-lying ground and partly on the slopes enclosing it, and there is a station on the East Lancashire line from which the semicircle of alluvial ground is well seen.

There are several large mills in the village, and the river has been much diverted from its old course to feed the necessary lodges and ponds; but beside these alterations there has obviously been a change in the river-bed, made before the mills were built or the water-courses cut; and even a superficial observer, standing on the hill above the railway station, would be struck, I think, with the probability of the river having run round the circumference of the semicircle, instead of as now, along the diameter.

The question would consequently arise, "what caused the alteration?" It cannot be the wearing away of the banks,

because the well-known law of rivers is that they scoop out the outer, not the inner side of their curves, and the wearing away of the bank would consequently increase, instead of diminishing, the distance travelled by the stream. After many visits to the spot at various times, I am inclined to the opinion that the river did run formerly along the outer curve of the valley,—that, in fact, it caused the valley, and that the slipping down, winter after winter, of an immense mass of northern drift on the side of the stream, gradually overcame the force of the water and drove it back.

This predominance of the landslip action over the wearing of the river would not take place until the stream was much reduced in speed, either by a decreased rainfall, as woods were felled and forests cleared, or by the partial blocking up, at a place called "Forest," of the outlet of the water. If the rainfall were lessened, the violent winter floods would be less frequent and less powerful, and if the outlet were closed, a lake would form above the obstruction, and the drifts would meet with but little resistance in their continual effort to fill up the channel.

That the river was held back at the narrow gorge of Forest, is, I think by no means improbable; and that the drift deposits are continually slipping down may be plainly seen after any long continuance of wet weather.

The soil of the low ground is alluvial, and quite recently, when the foundations were being dug out for some gas works, a number of large oak trees were discovered, lying under many feet of coarse river-gravel and sand, deeply stained, and saturated with water. These I saw, soon after they were laid bare, having been informed of their discovery by Mr. John Hall, of Baldingstone, a member of this Society; they lay in various directions and had been much water-worn before they were deposited in their present position; the outer portions were as soft as cheese, the

inner firm and sound; they lay at various depths and were in different stages of preservation.

Above them, on the side nearer to the present river-course was a thin line of peat, not more than half-an-inch in thickness, and a layer of sand, deeply stained with iron oxide, and both above and below them were hundreds of large and small boulders, many of which appeared to have travelled no great distance in the river, but to have rolled down out of the drift deposit which lies immediately above the place: mingled with these were small stones and gravel, which belong to the rocks of the neighbourhood and were rolled quite smooth.

The points, therefore, that I wish to advance are that the Irwell in the days of its might, scooped out this valley of Brooksbottoms, and then, when it declined in power, the gravelly banks encroached upon it, driving it back year by year, aided perhaps by a temporary damming up of the water, until the course was removed some 50 yards from the old channel.

Similar deposits of tree-trunks and of peat with hazel nuts have been noticed, I am told, near Clifton, and at other points on the river, of which some specimens have come into my possession, and lie now on the table for inspection.

Mr. De Rance said that one or two points had presented themselves to him, in the valley of the Ribble, which appeared to throw light on this interesting paper. They had in the Ribble an analogous valley to that which Mr. Crofton had described in the Irwell, banks of glacial drift 180 feet high, at the foot of which occurs the ordinary alluvium. On the banks of this drift there were river terraces, one below the other, and when these were examined they were found pretty generally to contain one sequence of deposits: first a fine mud, then a peaty bed containing very often trunks of trees, and beneath that, very large gravel. It was quite

clear, as they had a valley 180 feet deep entirely excavated in these drift deposits, the formation of the whole of that valley was of a later date than the deposition of those deposits which originally extended right across. In other words, the Ribble valley between Preston and Blackburn was entirely post-glacial. When they examined the terraces referred to—take the lowest for example—they had at the top a fine material, and at the bottom larger gravel; and it would seem the latter represented the period of denudation, the fragments it contained being entirely derived from boulder beds above. It was clear from an examination of these terraces, which were nowhere better marked than in the valleys of the Irwell and the Mersey, that the lower ones were the more recent, and the lowest level of the plain was the newest in point of time. In examining the alluvium of such a river as the Ribble they found the same sequence of events. It was evident that a period had been arrived at when very little denudation was going on and fine flood-matter was brought by the rivers and spread abroad over the country; but there was one interesting thing in connection with those beds. There was a peaty seam, with trunks of trees, in the Ribble valley lowest alluvial plain: in following that out into the great peat plain of Lancashire they would find the deposition of the latter continuous in point of time with that particular peaty seam which was found at the bottoms of the broad valleys, therefore he could not but think that the forests which grew in West Lancashire before the deposition of the thick peat of Lancashire belonged to about the same period of time as those trees which were so frequently turning up in the bottoms of the river valleys, and that the peat was somewhat newer, in time, than the trees found lying at the bottom of the alluvium which forms the lowest plains.

Mr. Woodward said that a specimen of oak shown by Mr.

Crofton, from Clifton, was only a small proportion of what had been found there. Trunks of trees had been found 18 or 20 ft. long, and from 1 to 2 ft. in diameter. Above them lay a bed of clay 3 ft. or 4 ft. thick, and below that again a boulder and sand bed. Where the trees were found there was a peat bed 2 ft. or 3 ft. thick, and almost immediately below it a coal seam about 2 ft. thick. Excavations were still being carried on, and a further considerable deposit of oaks would probably be found.

The PRESIDENT said there was one point on which he desired to say a few words, the correlation which Mr. De Rance had made of the peat layer which contained the tree trunks, to the rooted stumps of the trees which occur beneath the peat of Lancashire. It appeared to him (the President) that that was a very important correlation, because they knew that the buried surface of forest growth was one which was not at all peculiar to the peat of Lancashire—but that it occurred all along the sea board of Lancashire, wherever there was any great stretch of sand exposed between high and low water marks. Whether it were Fleetwood or Liverpool, made no matter: there they got the same stumps of trees which could be traced inland to the trunks which were to be found underneath the great deposit of peat at Chat Moss and in other similar localities. The ancient forest extended around our coast, occupying the same horizon from some point near, or below, high water mark to some 20 or 30 ft. below low water mark. With regard to its precise geological position, he thought that point was satisfactorily settled by the remains of animals which were found in it. They found, amongst numerous other species, the ox which was introduced by the neolithic peoples into Europe—the *bos longifrons*, or short-horned ox—now found to be living in the small Welsh black cattle. Then there were the roe

deer, the red deer, and the wolf; they also got a few remains of the bison. All these animals were found in association with trunks of trees, and they evidently arrived in this area at a time when those trees were living and constituted a forest. This forest, from its range below low water mark, must have grown at a time when this country occupied a far greater geographical area than it does now. The presence of the *bos longifrons* stamped further the fact that that time was after the introduction of that species of ox by the Neolithic peoples. In other words, the date of the growth of these forests—the time when they extended to a distance considerably beyond the present coast line—was no further back than the time when people using polished stone axes were in possession of Europe. This was a very interesting question. It touched the fringe of a very large subject, a subject which bore immediately on great physical changes that took place in this country in comparatively modern times. With regard to the destruction of trees by peat, that was a most simple thing. From what he had observed in Somersetshire—in the great levels, which occupy a considerable area—the same sort of thing had happened. First of all a forest had grown, consisting of oaks and the like—oaks, however, were the most prevalent trees—very little removed above the level of the nearest river. In course of time, the river-course had silted up, so that the stream had eventually to flow at a slightly higher elevation than the surrounding plain. Of course the tendency of materials brought down by floods would be to bank the river up, but that bank not being perfect or continuous, it ultimately came about that the river flowed upon the crown, so to speak, of a sort of arch. But that did not frequently define its course all the year round; in winter the flood water flowed into the area occupied by forest, and then, what was an area of forest-growth became converted

into a stagnant morass. The trees rotted at the bottom, died, and were blown down one by one, according to the direction of the prevalent winds. Ultimately all got blown down; and then the stagnant morass gradually became converted into a peat bog by the ordinary processes of vegetable decay.

Mr. DICKINSON said with regard to the change of level which the President had alluded to as having taken place on the Lancashire Sea Coast, he thought there was no question that that change was due in a great measure to the solution of beds of rock salt, which formerly under-lay that portion of the county. Baines in his *History of Lancashire*, gave the date when Brine springs ceased to flow at the Meres, near Birkdale, two or three miles from Southport. The same stratification was visible at South Shore, Blackpool and elsewhere along the coast.

The PRESIDENT said that Mr. Dickinson's hypothesis would hardly work, in this particular case, because the remains of forest were found below high water mark in regions where there had never been any rock salt—not merely on the western coast of Lancashire, but all round our coasts, for instance in the Bay of Cardigan, in the estuary of the Severn, and all along the coast of Somersetshire; likewise in the South of England, all along the coast; wherever they found a shelving shore, there they got this identical peat bed. It was the same on the eastern coast, and even in the north of Scotland; so that the change of level was not at all a partial one; it was not dependent on any one set of rocks but was found to affect the country generally.

Mr. DICKINSON observed that each case ought to be dealt with on its own merits. In some of these instances named by the President the depression might be attributed, he had no doubt, to the cause he, Mr. Dickinson, had alluded to, with reference to the Lancashire Coast.

The Rev. A. Crofton briefly replied, and stated that to his knowledge, peat deposits were found on the coast at Hastings, on the Weald. This was a fact which militated against the rock salt theory.

THE LANCASHIRE COALFIELD.

The adjourned discussion on the paper read before the Society, in March, by Mr. C. E. De Rance, F.G.S., "On the variation in thickness of the Coals and Measures of the Lancashire Coalfield," was resumed.

Mr. De Rance said he wished to mention that at the former meeting, when he read his paper, Mr. Dickinson asked his authority for one of the sections—the Burnley section—and whether it had been copied from a section prepared by Mr. Wild, and published some years ago in the Transactions of this Society. He (Mr. De Rance) was, at that time, unable to give Mr. Dickinson information as to the source from whence his colleague, Professor Hull, procured the section; but he stated that it was reduced from a published section of the Geological Survey in the neighbourhood of Fulledge, and one in the neighbourhood of Cliviger. Not being able to get one continuous section, from the top to the bottom of the series, he was forced to connect those two sections into one column. He had since found that Professor Hull obtained the Fulledge Colliery section from the late Sir J. P. Kay-Shuttleworth; and the lower, or Cliviger section, was procured from Mr. Jobling, who was manager of the Colliery at that time. In correlating two sections which were some distance apart, of course it was difficult to ascertain the precise distance betwixt the Great Mine, which was the lowest coal of importance in the upper section, and the China or 2 feet seam, the highest coal in the next section; and Mr. Strahan,

who drew up the Burnley section, on arriving at that particular point wrote "thickness doubtful." It might be—though he would not say that it was the fact—that there was, in the lower portion of the sect on a certain gap where measures ought to be which were not represented at all in the column; but above that point, the section rested upon the accuracy of the section given to Professor Hull by the late Sir J. P. Kay-Shuttleworth. The accuracy of the lower portion rested on information given by Mr. Jobling: the only point of uncertainty was in the correlating one up into the other. He regretted that the Burnley column was made up of two sections, which were two miles apart, because in those two miles it was quite evident the thickening had taken place, as at Wigan, in the direction of the centre of the basin. That being so it would clearly be worth while to produce a set of sections across the Burnley Coalfield, in two different directions, on the same system that the present section had been drawn up. He had to thank the Society for the kind way in which his communication had been received. Gentlemen could hardly imagine the difficulty often involved in settling even a small point in preparing such sections. Some little thing, in reading through a section was seen to be probably inaccurate, and to settle the point, journeys in this and that direction were necessary, and they had to enquire of people whom, it might be they had already troubled too much. He assured the Society that, simple as the sections looked, they had been the source of much anxiety and trouble.

Mr. Dickinson said he was glad to see the Burnley section put right, because it had been a blot in the Society's Transactions for some time. It would have been a pity to have had it perpetuated in a new paper. He was not aware of the difference to which Mr. De Rance had alluded, as to the variation of the sections at Burnley, but he did know this—

that in some of the sinkings the distance between the so-called King coal and the Arley mine varied. That, however, was explainable by the fact that some of the shafts which had been sunk had crossed faults in the way. It might be taken as an axiom that in sinking a shaft through measures which lay so nearly level as those at Burnley, they could only shorten the distance of sinking between seam and seam. The crossing of a fault could not lengthen the distance: it invariably shortened it. Some Burnley shafts which had passed through that so-called King coal, down to the Arley mine, had crossed faults, and necessarily shortened the distance. The fixing of that as the King coal was, of itself, a very arbitrary proceeding. The whole of the Burnley coalfield was only connected with the main coalfield of Lancashire in its lower members: the Mountain Mine series was continuous from Burnley to South Lancashire, but nowhere was the Arley Mine continuous, and in the seams overlying the Arley, including this so-called King coal, there were very great changes. The "King coal" in the Burnley coalfield varied, itself, very considerably. In some places it formed an immense seam, about a dozen feet thick, lying in one mass; in other places it was divided out into beds several feet apart, and whether it was the King coal or not was doubtful. It might, for anything that was known, be a representative of the Plodder, or some of those mines; so that assuming none of the shafts to have been sunk through faults, the general principle, as regarded this thinning out of strata, was borne out by Mr. De Rance's paper with regard to those seams in the Southern part of the coalfield only.

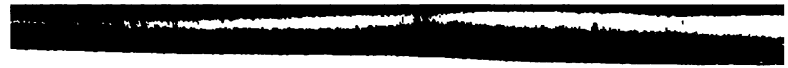
Mr. J. F. Seddon said that from the comparatively small knowledge he had of the Burnley district he was enabled to some extent to corroborate Mr. De Rance's remarks as well as those of Mr. Dickinson. He perfectly agreed with

Mr. Dickinson that the correldation of the Burnl
with that of S.W. Lancashire was complete
lower mines. He did not think that the so-c
Coal at Burnley, is rightly placed in the section,
was not prepared to enter into an argument w
Rance upon the section Mr. De Rance might try
him that it was rightly placed but he did not no
On the other hand the mines as shown in the Wig
in Mr. De Rance's section were from his own kn
them to a large extent what Mr. De Rance had
to be; and also at Burnley, his knowledge of the mi
him to believe that, with the exception of the gap to
De Rance had alluded, they were moderately correc

The PRESIDENT said it seemed to him that the
drawn by Mr. De Rance from these sections were
which, geologically considered, were absolute b
possibility of correction. If the sections were tru
De Rance's conclusions must, on the whole, be
With regard, however, to one of his conclusions-
to say, that the deposition of the lowest coal me
followed by a continued subsidence, and that, aft
an upheaval took place by which lines of faul
north and south were produced, he thought that
sition was one which had not altogether been p
was undoubtedly true that the flexures were proc
the deposition of the coal measures, but it was
from the evidence in the paper, that the faults were
after the flexures. It seemed to him extremely pr
some of those faults might have been formed a
when some of the flexures were formed. Reflect
mode in which the flexures were produced it seem
almost necessary that some faults must have beer
at that time. These flexures, be it remarked, we
by lateral pressure. That lateral pressure was pr

subsidence: that was to say, there was a subsiding area on the earthy crust which sank whilst the rest did not sink at all. It seemed to him absolutely necessary, if that by hypothesis that there should be a fault between the portions of the earth's surface which remained *in situ* and the portion that subsided and caused these flexures. It was, therefore, exceedingly likely that some of the faults affecting the coal measures that have been produced at the same time as, on even before, the flexures.

Mr. De Rance in replying said that on this question of faults he had been guided by researches of Mr. J. M. Wilson, M.A., and the ground he had taken up was that the flexures were produced by one set of motions at one period and the faults by another set of motions at another. The President had taken exception to this; but it was so large a question that he (Mr. De Rance) must be excused if, at that time, he did not go into it. His great object in bringing those sections before the Society was to show what they were doing, in the Geological survey, in arranging sections in definite directions. These, it seemed to him, threw practical light on matters of great importance for Geologists to know; and the Society, numbering amongst its members many colliery managers and mining engineers, was peculiarly fitted for carrying out such investigations.



TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIII. VOL. XIV. SESSION 1876-7.

The CONCLUDING MEETING of the Society, for the Session, was held at the House of the Literary and Philosophical Society, George Street, on Tuesday, 23rd June, 1877;

Mr. JOHN AITKEN, V.P., F.G.S., in the Chair.

The following gentlemen were elected Ordinary Members: Mr. Jos Derry, Sneyd Collieries, Burslem; Mr. Robert Handsley, Burnley; Mr. John Jobling, Cliviger Collieries, near Burnley; Mr. James Lord, Stonehill Colliery, Farnworth; Mr. Henry Waddington, Burnley; Mr. J. F. Walton, Fern Lea, Rawtenstall; and M. Charles Brongniart, Paris; M. Ernest Vanden Broeck, Brussels; Dr. F. V. Hayden, F.G.S., State Geologist, Washington, U.S.A., were elected Honorary Members of the Society.

REMARKS ON THE RECENT GEOLOGY OF ITALY.

SUGGESTED BY A SHORT VISIT TO SICILY, CALABRIA, AND ISCHIA.

BY ARTHUR WILLIAM WATERS, F.G.S.

In a paper* I read a few weeks ago, in this room, to another Society, pointing out how much more satisfactory an explanation a geographical change of the position of the axis of

* "Enquiries concerning a Change of Position of the Earth's Axis." Proc. Manchester Lit. and Phil. Soc., March 6th, 1877, vol. xvi, No. 10. This will shortly be published in full in the Transactions of the Lit. and Phil. Soc.

the earth would give of the warm periods which have existed in high northern latitudes, than any other that has yet been brought forward, I suggested whether the very large and constant changes of the land and sea might not furnish an explanation of a much larger variation than when the amount of ultimate change alone is considered. I then casually said that "if we turn to the North of Europe as in Belgium; or to Italy, we find for a general elevation of a few hundred feet to have taken place since the middle of the tertiaries there have been subsidences and elevations of many thousand feet." I said this as being the countries in which I had more closely considered these changes, but not as being those in which of necessity the changes had been more than in other lands.

I have, therefore, thought that a few remarks on a visit to Sicily and Calabria, and to the Island of Ischia, to each of which places I was only able to devote a few days, may give me the opportunity of showing the members of this Society that the remarks were not made without sufficient ground.

The formation in each of the places about to be considered is recent tertiary.

As I am speaking to geologists I do not need to remind you of the general classification of the tertiaries, as no doubt all present are fully acquainted with Lyell's works, and know that he divided the Cainozoic into three divisions, according to the per centage of species now living, which the fossil mollusca furnish. The Eocene (the oldest division), according to the knowledge at that time of the fossil and living fauna, had 3½ per cent. of recent species, as in the Paris and London basins; the Miocene 17 per cent in the Loire and Gironde; the older Pliocene 35·5 in the Sub-apennine formation, while the newer Pliocene had up to 95 per cent. of species identical with those now living. With

additional knowledge these figures will be slightly altered, but what has been once fixed as typical Eocene, Miocene, or Pliocene, should always remain so, independently of additional faunistic knowledge. .

But if we desire to follow the history of the globe with any exactness it will be seen that we must be able to compare formations in distant places, and that we shall require to know that when Eocene, Miocene, or Pliocene is spoken of, that the same thing is always meant, and we shall also want a more minute division, and for this each has been divided into upper, middle, or lower. If there had been uniformity in using these terms they might have answered every purpose, but as they have been used to mean different formations it is impossible to know, when comparing works by different authors and in various countries, without the most careful study, what may be meant when Eocene or Miocene rocks are spoken of, and this is the case also with the term Pliocene, though not to so great an extent.

Although it requires research, and often a very large acquaintance with the tertiaries, to be able to solve the meaning intended by the terms used, an unnecessary difficulty has been introduced by the creation of an intermediate formation—the *Oligocän, as it was thought that certain fossiliferous deposits contained mixed Eocene and Miocene species, or in other words it may be said to have been invented to get over the uncertainty which had arisen when upper Eocene and lower Miocene were in discussion; but this period, though comparatively meagerly represented in those localities which had been taken as typical, were yet present, though not so luxuriantly as in the E. and S. East of Europe. These deposits were certainly formed under different conditions, and the fauna of these distant parts

* Ueber die Stellung der Hessischen Tertiar bildung H. Beyrich, Berichte d. Akad d. Wissen, Berlin, 1854.

was then different, so that while the Miocene of Fontainbleau was being laid down, fossiliferous deposits were being formed of great extent, and extending over a long time in the North of Germany, in Styria, and in the Vicentine, and other parts of Europe, which in their southern extension are full of a few species of Nummulites, a genus of foraminifera which existed in the Eocene in a very large number of varieties or species according to our tastes; but in these Miocene beds of the South East of Europe there were only a few species as the Nummulites striata, variolaria, intermedia, mamillata, biaritzana. To this period belong the faunas, so rich in corals, &c., described by Reuss and Fuchs, and called by geologists Oligocän, together with the upper Eocene of Lyell; but great as is the confusion between Eocene and Miocene, it is as nothing to the Oligocän chaos, and we may safely say that no one from the talented author of the term downwards now knows what Oligocän is. I have found in conversation with English, German, Austrian, French, Belgian, and Italian geologists that the feeling is with most very strong that it is an unfortunate division, but yet it has been so largely introduced that though it is almost universally felt to be a superfluity it is constantly used, and it is doubtful if it can be eradicated.

These terms have all been coined to enable easier classification, and for the facts to be more easily grasped, and it is an agreeable surprise to find that when we turn from terms to the interpretation of facts there is not so much confusion, for although the same beds may be called lower or middle Miocene; Oligocän, upper, middle, and lower; or upper Eocene, yet we may find the leading geologists throughout Europe all agreed that they are of the same age as well-known and typical beds which they variously designate.

Prof. Carl Mayer, of Zürich, who has specially devoted himself to the tertiaries, has endeavoured to arrange synchronetically the tertiaries of Europe, and his work, which will

require with increased knowledge considerable modification in some points, will nevertheless remain a most important landmark in the study of these formations.

He divides into * fourteen étages, and takes for each some typical or early studied locality, on the same principle that there are in the Paleozoic and Mesozoic eras, Devonian, Laurentian, Silurian, Jurassic, Oxfordian, and Wealden. These stages can in most cases be subdivided in those localities where they are well developed, as for instance in Belgium, the Tongrian can in the neighbourhood of Tongres be divided into two or three *sous-étages*, and so with the others.

Briefly considering the relative position of those beds we are about to examine, we find the European chalk closes not with the English white chalk, but with beds more recent at Maestricht, in Holland; and the lowest tertiaries are found also in the same quarter of Europe (in Belgium), and are classed as Flandrian or Garumnian; then follow the Reading beds, then the London Clay, which we know attains such considerable thickness at Sheppey, to be followed by formations of the age of those best known in the wonderfully rich Paris basin, as at Grignon. Then came the Bartonian, the Ligurian, with its enormous deposits of Flysch in Switzerland and Italy, the Tongrian, Aquitanian, Langhian, Helvetian and Tortonian, in all of which we might see, if examined in detail, that great changes took place in the geography and the life of the places represented, and that each shows a record of vast time, and those who have given attention to this branch of geology will feel that the greatest changes of the Caniozoic period have taken place, and that in fact we are now getting to the close of the tertiaries, but the formations represented by the fossils on the table belong

* Ch. Mayer Tableaux synchr. des terrains tertiares. Zürich, 1856, &c. Ed. 4me. 1869.

Ch. Mayer Essai et Prop. d'une classification nat. aus dem Programm der Eidgen Polytech. Schule, 1874.

to these later stages, and we shall see how much the crust of the earth has been moved even in these later formations.

Table of the divisions of Mayer :—

Lyell.

Saharian	Pliocene	Ligurian	Eocene
Astian		Bartonian	
Messinian		Parisian	
Tortonian.....	Miocene	Londinian	
Helvetian.....		Soissonian	
Langhian.....		Garumnian or Flandrian ..	
Aquitanian			
Tongrian			

Cretaceous.

When the geology of a fresh district, or country, is attacked, the formations must naturally at first be divided according to the salient geological features of the district, and the names given are sometimes lithological, sometimes after the principal localities, sometimes according to the leading fossils, and only after careful study can they be correlated with distant formations.

Prof. Seguenza has undertaken the study of the * Sicilian tertiaries, and has already published stratagraphical lists of some thousands of fossils.

The divisions he makes are into zones which he correlates with Italian formations. The Eocene are divided into 4 zones; the Oligocän, 2; the Miocene, 6; the Pliocene, 4; and the Quaternary 2 zones.

The Miocene in Sicily attains considerable proportions, for in many parts the great conglomerate beds alone are 1500 feet in thickness, and considerable changes of the

* Notizie succinte intorno alla costituzione geologica dei terreni terziarii del distretto di Messina per G. Seguenza, Messina, 1862.

Brevissimi cenni intorno la serie terziaria della Provinzia di Messina per G. Seguenza. Boll. del Reale Comitato Geologico d'Italia, vol. IV., 1873.

Studii stratigrafici sulla Formazione pliocenica dell' Italia Meridionale per G. Seguenza. Boll del R. Com. Geol., 1873—1877 : in progress.

relative level of land and sea are also here shown in the Miocene. The fossils indicate considerable depths for the lower beds—at least some hundreds of feet—when there must have been a raising of the land, and then must have followed the sinking for this conglomerate formation of more than 1500 feet to be formed. This was followed by a rise when a considerable part of the neighbourhood was dry land, and the lignite formation had time to be formed, and Rhinoceros and Sus choeroides wandered through the forests and over the hills.

The Miocene, according to Seguenza, ends with a molasse alternating with sands, clays, and lignite, which he considers to be Tortonian.

The lowest division of the Pliocene is zone 4* of Seguenza, which is a whitish marne, very full of foraminifera, with which in some places alternates sand and limestone, and in parts is rich in corals and other fossils. These indicate that there was a deep sea in the neighbourhood of Messina, and over a great part if not all of Sicily and Calabria. As this formation indicating deep sea is of great thickness, to estimate the amount of change of level this thickness must be added to the depth at which such a deposit could have been formed. I am not aware of the maximum thickness, but it will be not less than 300 feet in many places where I saw it, and the foramifera would indicate a depth of at least 1000 feet. Now, as littoral formations belonging to the upper zone of the Miocene (Tortonian) are known, we see there must have been sinking of considerable amount. In most of South Italy the Pliocene commenced in a deep sea.

This zone is called by Prof. Mayer †Messinian, from being characteristically developed in these localities; and, as far

* It is to be regretted that Prof. Seguenza has not retained the same numbering for his zones in his various papers, as in his Studii Stratigrafici, loc. cit zone 6 is zone 4 of the Pliocene in his Brevissimi cenni loc cit.

† This is the Zanclean of Prof. Seguenza.

as present knowledge enables a judgment to be formed, are usually considered of the age of the English Coralline Crag. In some parts of Sicily there are with the marne beds also sand strata, indicating change of level; but much clearer proofs may be found in the North of Italy, where marine strata alternate several times with fresh water, containing beds of lignite, and furnish proofs that during the periods of elevation forests have grown and flourished, and have then sunk below the sea level, and been covered with marine strata before another elevation formed them into dry land, for forests again to grow and be buried.

M. Pareto* says, when speaking of the Sienna beds, "trés remarquable a cause des alternances multipliees de couches marines et de couches fluviatiles." And, in another place, "je ne pourrais ajouter que des particularités servant à prouver que les alternances des couches fluviatiles, et marines sont bien plus nombreuses encore qu'on ne le croyait."

The third zone of the Pliocene is that which is best represented in the North of Italy, and contains part of the blue and yellow marnes into which the Italian Pliocenes have usually been divided, and which are characteristic formations of the North of Italy.

Prof. Seguenza, who has for so long most ably worked at the tertiaries of Sicily, is now publishing, as already stated, lists of the fossils from the various zones, and in the Bolletino del R. Comititato Geologico has already (April number) given 1183 fossils of this zone, with the localities where they are found. And this list will apparently be some hundreds more before it is completed; but I find that 45 per cent. of the mollusca are of species now living. This number includes only the mollusca, and as there is also a

* Note sur les subdivisions que l' on pourrait établir dans les terrains tertiares de l'Apennin septentrional, par M. le Marquis L. Pareto. Bull. de la Soc. Geol. de France. 2me ser. tom xxii., 1864—1865.

goodly number of Corals, Bryozoa, Foraminifera, and Echinodermata, the number of known fossils from this zone will now be over 2000.

The proportion alone is not an entirely satisfactory method of correlating distant formations, as so much depends upon the character of the beds, if deep or shallow water prevailed, and also upon the individual tastes of the author, for some have a much greater delight in a multitude of species than others. But in examining any locality, as seen in Sicily, it yields most important results.

I do not feel at all competent to form any decided opinion on the correlation with the English Crags, but the correlation of this deposit with the rest of Italy seems more satisfactory. According to Mr. Searles Wood, in the Red Crag, which these beds are usually supposed to represent, 25 per cent. are extinct species, and 31 per cent. in the Coralline Crag supposed to be of the age of the last zone.

It must not be forgotten that the changes will naturally have been much greater where the glacial conditions have exerted so much influence, and where changes could be introduced from larger areas, and this, I think, should be always kept in mind, where an attempt is made to correlate distant formations, as for instance, the Australian tertiaries. Such studies should receive great assistance from geographical reconstruction as soon as that becomes a possibility, and although it may seem very visionary at present, I cannot help thinking that future generations of geologists will find this a most useful adjunct in determining relative age.

Zone 2 and 3 are the Astian of Prof. Mayer. The name is taken from the well-known Asti deposits which, according to a comparison made some time ago, contained 42 per cent. of species now living. Although the conditions of deposition are different, for in Sicily zone 3 was mostly a deep

sea formation, while in the North of Italy as at Asti it was littoral yet independently of the proportion, both paleontologically and stratigraphically, it has been proved that part of these were of the same age.

The unconformability of this zone in many places with that below shows that great local changes took place in these lower Pliocene beds. At this time it would seem as if the sea was deepest somewhere about the locality of Messina; while on the flanks of the cristalline mountains of Calabria there are littoral deposits.

When we proceed to the next or second zone of the Pliocene, the comparison with the rest of Italy is not so easy, because at this time nearly all the North was raised above the sea, so that marine deposits are mostly wanting, but near Leghorn and at the Vatican Hill, and Monte Mario near Rome deposits of about this age permit comparison, and show the relation to the other deposits. Prof. Seguenza gives a list of 332 species, of which 22 per cent. are extinct. This is considered to be about the age of the Norwich Crag, which contains 17·5 per cent. of extinct forms.

Near Messina there was still deep water for the greater part of this period; but in some places, as at Altavilla, near Palermo, the fossils prove littoral conditions, and it is these which enable a comparison with the Leghorn beds. Whether the Serravallian of the Marquis de Pareto, of the North, corresponds with part of this zone and the next, is at present somewhat difficult to decide. In the Serravallian no marine formations are known in the North of the peninsula, but fresh water shells and a number of mammalian bones have been found, showing that there were a number of lakes, and that all had been elevated above the level of the sea.

We have seen that although there have been constant oscillations, yet, on the whole, the indications have been of

decreasing depth; and so, also in the uppermost zone of the Pliocene, or zone 1 of Seguenza, the same thing is apparent, as it is mostly littoral; and also there are indications of gradual decrease of temperature. Professor Seguenza has also made out a list of fossils from this zone, and out of 829 species 130 are not known living, or 15 per cent. are extinct as far as present information is available. In different localities the proportion varies, as at Reggio and Taranto, 4 per cent.; at Ficarazzi, 12 per cent.

Whether this should be placed as *Saharian of Mayer, I at present feel some doubt.

To this zone must belong the fossils from Nizzetti (on the flanks of Etna), as published by Sir Charles Lyell in the Phil. Trans., 1858, vol. 148. Out of 142 species 11 were said to be extinct, but I find that since the list was made out† two, viz., Cancellaria coronata Seg. and Murex multilamellosus Phil. have been discovered in Sicilian seas.

The top of the Pliocene has now been reached, but not the end of great changes in Sicily and the South of Italy, for also in the quaternary considerable deposits and great elevations and subsidences took place, and now we have "alluvione" and sands, with fossils identical to those living at present. This we see the best at Reggio, but I

* This term of Saharian, as also that of Langhian seem to have been remarkably unfortunately chosen, but names should not too readily be changed, and therefore it will be better to wait until there is sufficient reason before alteration is made. There do not seem to be any Sahara beds of which the age is sufficiently definite to be taken as a type, and for such a purpose a locality nearer to other typical localities should be selected. It would seem that another *étage* is required after the Astian, but a representative formation could only be found in the extreme South of Europe or the North, as in England or Belgium, as the central countries were then above the sea. I have found it quite impossible to make anything out of Mayer's Saharian, but I suspect that although the North of Europe couches that he gives as of Saharian age are of the time of this zone 1, yet that the name was originally given for a much more recent period.

† Conchigliologia vivente marina della Sicilia, by Prof. A. Aradas and Cav. L. Benoit. Atti dell' Accademia Gioenio di Sc. Nat. di Catania ser III., vol. III., 1870.

have not been able to find the thickness of these beds or the height up to which it occurs, but it is found many hundred feet above the sea level.

It was after the Pliocene that Mount Etna has been built up to a height of nearly 11,000 feet by a large number of eruptions throwing out ashes and pouring forth lavas on to the mountain slope. The fossiliferous deposit * containing only nine species not known living, were found at a height of nearly 1000 feet above the sea level, and is overlaid by the lavas. Although these nine species are not known living, the bare statement of the figures gives a somewhat erroneous idea, for with one exception these nine are extremely rare in the fossiliferous beds, so that they are only the rear guard of the defeated army, and the fauna was essentially similar to that obtaining at present in the Sicilian waters.

As there has been a most unfortunate difference of opinion regarding the Gerace Pliocene beds it seems advisable that before passing from the Pliocene I should give the section as it appeared to me, at the same time saying that it is certainly most important that someone already well acquainted with the sequence of other Pliocene beds either in the Messinese or Reggiano, should carefully examine it as according to the notes I made it does not wholly correspond with the interpretation of the sequence of the Messinese Pliocene, as given by Seguenza. My notes were made quite independently of the points in dispute between †Professor Fuchs and ‡Professor Seguenza, and my short visit was made for my own instruction rather than research.

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* See page 261.

† Geologische studien in den tertiarbildungen Süd-Italiens von Theodor Fuchs. Sitz-bericht d. Akad. Wissen Wien, 1872.

‡ Papers in the Bolletino del R. Comitato Geologico d' Italia have appeared from Professor Fuchs and Professor Seguenza from 1874—1876 on this discussion.

beds in descending order are at Gerace (Calabria) :—

rozoa limestone, yellow, about 190 feet, in some places very full of Amphistegina.

ıd, in some places, contains Pecten polymorphus and Terebratula.

rne. In some parts with very large Nodosaria, Robulina cultrata, Textularia, &c. This mergel is in most places almost composed of foraminifera, principally Orbulina universa.

la Scillae Seg.	rr.		
lina caput serpentis L.	rr.		Eocene—living.
(Bulla) lignarius L.	rr.		Eocene—living Brit. Medit.
convoluta Broc.	rr.	P	Lower Plioc. of Sic.—living.
a carinata Bivon. (modiola)	c.	P	Pliocene zone 1-3, living.
vulpeculus Brocch.	cc.	P	Pliocene.
ratus Olivi	c.	P	Pliocene zone 1—3, living.
chella Phil.	r.		Plioc. of Sic. zone 1-3, living.
ulata Brocc.	ccc.	P	Lower Plioc. of Sicily.
matica Brocc.	c.	P	Miocene—living.
ltilamellosus Phil.	c.	P	Pliocene zone 1-3, living.
pes-pelicani L.	cc.	P	Miocene. Pliocene—living.
Architae Aradas	rr.		Living.
filosus Phil.	ccc.		Lower Plioc. Sic.—living.
suturalis Phil.	rr.		
ris Don			
elephantinum L.	ccc.	P	Mioc. Plioc. zone 1-3, living.
entalis L.			Eocene Sic.—living.
rubescente Dub.			Living.
dentalis L.			Plioc. Sic.—living.
culeatum	rr.	P	Living.
ua Phil.	cc.		Sic. Plioc. zone 1-3, living.
ra Phil.	cc.		Tortonian—Upper Plioc.
aurita Brocc.	ccc.	P	Living, zone 1-3.
sa Phil.	cc.	P	Pliocene sup.
aritacea	r.		
Phil.	r.	P	Pliocene.
lcuta Phil.	cc.	P	
ia acuticostata Phil.	rr.		Older Plioc. of Sicily, living in Northern Seas.
s felis L.	r.		Upper Plioc. of Sicily, living.
temradiatus Mull.	r.	P	Mioc. Plioc of Sicily. living.
briatus Phil. (Hochinsii Forbes)	c.	P	Pliocene of Sicily, living.
tiquatus Phil. (fenestratus ,,)	c.	P	Living.
inifera Mont	r.		Miocene, living.
truncatum		P.	Living.
orvnopus S. W.			Pliocene Crag.
rondiculata Lamour	cc.	P	Pliocene, living.
ns Manz			
s typus Seg.	cc.		Pliocene.
nsis Gold	cc.	P.	Miocene—Pliocene.

* Species printed in *italics* are not given in Fuch's list.

arge number of those marked living are now extremely

Besides these, which are all from one spot, I collected from the same beds in the neighbourhood:—

Nuculata dilitata Phil.		P.	Crag. Plioc. zone 1-4, living.
Natica sordida			Miocene, living.
Murex vaginatus			

And* Prof. Fuchs gives in his list from the same place—

Buccinum spinulosum Phil.
Cassidaria echinophora, Lam.

I have a fragment which I believe is the echiphonora.

Triton nodiferum Lam.	—
Pleurotoma nodulifera Phil.	—
„ harpula Brocc.	—
„ Vanquelini Payr.	—
Cancellaria lyrata Brocc.	—
Trochus marginulatus Phil.	—
„ granulatus Born.	—
Orbis foliaceus Phil.	—
Lucina digitalis Lam.	P.
Ceratocyathus communis Seg.	P.
Amphihelia sculpta Seg.	—
Lophohelia Defrancie E. & H.	—
Diphlohelia Meneghiniana Sig.	—
„ Doderleiniana Seg.	—
„ Sismondiana Seg.	—
Coenopsammia Scillae Seg.	—
Dendrophyllia cornigera Seg.	—

Below these beds, in some places, is a gravel, and in places a limestone, and then follows a blue unfossiliferous clay, mostly full of gypsum. This is Miocene.

Prof. Seguenza has disputed the sequence of Prof. Fuchs, and says that these fossiliferous clays are younger than the Bryozoa beds, saying that the presence of Amphistegina vulgaris, proves them to be the lowest of the Bryozoa beds, and belong to the older Pliocene, while the fossiliferous clays belong to the 3rd zone, and are younger. With this I cannot at all agree, as I find that I mention several times in my note book, these Bryozoa beds as above the mergel and fossiliferous clays. I will therefore give a section that

* Loc cit.

I saw near Rametto, which seems to show a certain amount of correspondence. Taking the strata again in descending order :—

1. Bryozoa beds lithologically similar to those of Gerace, containing Amphistegina vulgaris.
   Terebratula.
   Pyrgoma undata var Mich.
   Scalaria trinacria ?
   Pecten opercularis.
   „ Jacobeus.
   Isis melitensis.
   Echinocyamus pusillus.
   Cellepora pumicosa.
   Scrupocellaria scruposa. Miocene—living.
   Lepralia, perhaps ceratomorpha Rss.
   Lepralia spinifera Hass. Living.
   Membranipora annulus Manz. Lower Pliocene—living.
   Salicornaria farciminoides Johnst. Miocene—living.
   Myriozoon truncatum Pallas. Pliocene—living.
   Retepora cellulosa Cav. Miocene—living.
   Fascicularia tubipora Busk. Pliocene—crag.
   Pustulepora palmata Busk. Pliocene.

These beds seem to be considered by Prof. Seguenza to belong to the lower Pliocene.

2. Below this is a marnous sand for about 50ft., with large foraminifera, as Textularia, Nodosaria and Robulina cultrata. This by Arietta is only a few feet, and passes into clays with

3. Terebratula vitrea	—
„ Meneghiniania Seg.	—
Trochus filosus Phil.	—
Dentalium elephantinum L.	—
„ Sexangulum Gm.	—
Nucula sulcata.	cc
Verticordia acuticostata Phil.	—
Pecten opercularis.	—
Isis melitensis.	—
Amphihelia miocenica Seg.	—
Conotrochus typus Seg.	—
Coenopsammia Scillae Seg.	—
Flabellum messanese Seg.	—
Spines of Cidaris papillata.	—

4. Calcareous rock in which traces of fossils seem to have been destroyed by weathering.
5. Approximately 100 feet of marne with bands of conglomerate.

Then follows conglomerate with large crystalline boulder stones, mostly serpentine and gneiss, some 6 feet in diameter ;

then marne, conglomerate, marne, hard sandstone, in all, about 350 feet, below which is a Nummulitic and Lithothamnium limestone.

I also collected fossils at Pruma, in Calabria, which I take to be of about the age of the Gerace fossiliferous beds, underlying the great conglomerate of Reggio, which form a characteristic feature in the landscape, and has there a considerable extension. The fossils I obtained were, besides those marked P, from the Gerace beds:—

Terebratula minor.
Argiope truncata.
Pleurotoma Bertrandi Payr.
„ septangularis Mont.
Bulla ovulata Brocchi. Eocene—living.
Columbella.
Cerithium reticulatum. Miocene—living.
Rissoa abyssicola Forbes. Living.
Rissoa scabra Phil.
Cardita corbis Phil.
Arca Noae L. Aquitanean—Living.
Arca tetragona Poli. Helvetian—living.
Pecten opercularis.
Pecten polymorphus.
Lucina bipartita.
Loripes divaricatus L.
Lucina digitalis Phil.
Pectunculus glycimeris.
Astarte sulcata.
Hornera striata M. Ed. Pliocene.
Idmonea insidens Manz. Pliocene.
Idmonea triforis Hell. Living.
Salicornaria farciminoides. Living.
Discoporella mediterranea. Living.
Stephanocyathus Zancleus. Seg. Found at Rametto.
Cerytocyathus communis. Seg. Found at Rametto.
Operculina. One specimen.
Amphistegina. One specimen.

The number of fossils here similar to those found in the Bryozoa beds mixed with those of the clay beds is most instructive.*

* Prof. Fuchs, of Vienna, kindly lent me, shortly before I left Naples, a collection of Bryozoa, from the Lentini beds, but being otherwise engaged, I am sorry to say it has been impossible to unpack my large collections, and I have not yet been able to complete the determination of these, but hope shortly to be able to enter upon the examination of the fossil Pliocene Bryozoa I possess, and to compare them with my collection of recent Mediterranean species. I can only, therefore, give a provisional list of part of those lent me by Prof. Fuchs:—Cellepora retusa, Manz; C. tubigera, Busk; C. pumicosa; C. coronopus, S. Wood; Lepralia systolostoma, Manz; L. linearis; L. deliculata, Manz; L. biaperta, Mich; L. lata; L. ciliata, Pall; Membranipora angulosa, Ross; Salicornaria farciminoides; Retepora cellulosa; Discoporella radiata; D. mediterranea; Cupularia Reussiana, Manz Eschara cervicornis; Pustulopora proboscidea; Retehornera frondiculata; Frondipora reticulata; Myriozoon truncatum.

The great interest, which has been taken in glacial phenomena, has made not only geologists but also general readers acquainted with the fact of this island of Britain, and also other countries of North Europe, being not only during a part of the time many hundred feet lower relatively to the sea, but also at another time some hundreds of feet higher, and the same has been the case in the South of Europe.

*Mr. Hugh Falconer in a paper to the Geological Society, afterwards printed in his Paleontological Memoirs, pointed out that the Pleistocene mammalia of Sicily and of Gibraltar indicated that there must, about this time, have been a connection of Europe with Africa. This idea has been followed up by Prof. Busk and † Prof. W. Boyd Dawkins, who has shown by the presence of the Hyaena maculata, Felis serval, Felis caffer, which are African species, in the Pleistocene caves at Gibraltar: Elephas Africanus, Hyaena striata, near Madrid, and Hyaena crocuta, Hippopotamus Pentlandii, also African species in Sicily, as also by some of these at Malta, that there was land connecting these two continents, where there is now about 400 fathoms of sea. The geographical distribution of some of the living mammalia being stated to point to the same conclusion.

The flora gives similar results, according to ‡M. Cosson, for, of 1428 plants growing in Algeria 1056 are South of Europe species; and further, the flora of any part corresponds most nearly to that of the land which is opposite to it across the Mediterranean.

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* Quart. Journ. of the Geol. Soc., 1860. Paleontological Memoirs, Vol. II.

*† Physical Geog. of the Mediterranean, during the Pleistocene age, Popular Science Review, 1873. Classification of the Pleistocene strata of Britain and the Continent, by means of the Mammalia. Quart. Journ. Geol. Soc., 1872. Vol. 28.

‡ Tableau Physique du Sahara oriental de la Province de Constantine, par Ch. Martins Revue des deux Mondes, 1864.

As the seeds of plants may be more readily carried by birds, and even floated on the ocean, it is apparent that land and freshwater mollusca give a more satisfactory result, and *Burguignat says that the land and freshwater mollusca in North Africa show that between the African and Spanish species their reigns an almost complete resemblance, for of the 300 species he found in Spain he discovered most of the same in Algeria.

†Mr. Geo. Maw has also shown that elevation and subsidence, on a very large scale, has taken place in the North of Africa. He says there has been a subsidence of at least 3000 feet during the Tertiary period followed by an elevation of 4000 feet; then a Post tertiary depression when part of the Sahara was 2000 to 3000 feet lower than at present, followed of course by an elevation of about this amount. Mr. Maw does not give sufficient particulars to enable the exact periods of these movements to be correlated with those of Sicily, so that these elevations and subsidences may, or may not, have been at the same time as corresponding ones in Sicily.‡

I think I may here say that there does not seem any reason for supposing with §d'Archiac that because, as he says, at least half of the actual surface of the continents was under water during the tertiary period that there was less land then than now, and that portions now submerged were not then dry land, for the geographical distribution of plants and animals most distinctly proves the contrary to be the

* Die Sahara von Desor, 1871.

† Notes on a journey from Algiers to Sahara. Quart. Journ. Geol. Soc.

‡ I have not yet had the opportunity of working at the question of whether the connection of Africa and Gibraltar, and Africa and Sicily ceased at the same time or not. From a cursory examination I have rather got the idea that the Sicilian separation was earlier than the Gibraltar one, but I most distinctly wish it to be understood that I do not give any opinion on the question, but only indicate a line of investigation for someone else.

§ Histoire des Progrès de la Geologie, vol. 2.

case, and show there has been much land where there is now ocean. It is quite possible D'Archiac may now hold very different views, for his remarks look like a remnant of the teaching of the old teleological school, who thought that "the disproportion of the water to the dry land are circumstances more adapted to a race of fallen intelligences than to beings in a state of innocence."

We have seen how the deposits in the upper tertiaries of Sicily did not take place in steadily rising or sinking areas, but in areas of oscillations, and this is found to be the case in other places where the conditions are favourable for such a record being left, but of course this cannot always be found, as with a deep sea or with land no proof could remain. Such recent formations as those just considered are naturally much more complete than older ones, of which often in any district only a fragment of a page of a large volume remains, while here truly pages are wanting but the history is not very incomplete, and is only waiting for those who know its language. Nevertheless, very much the same thing is found to be the case in many if not all formations, as we may see in the Carboniferous or the Jurassic, though these cannot be worked out in the same detail, nor are we so intimately acquainted with the habits of the animals then inhabiting the sea as when all the genera are the same and most of the species identical, but much as we can learn it is only comparatively large changes that would reveal themselves to our researches; but when we look to periods within historical times, then works of man's art have enabled changes on a much smaller scale to be proved, and perhaps nowhere is this more clear than near Naples, which district we will now consider.*

* The movements of the earth's crust which have been mentioned may be represented by the line AA in fig. 2, but if we take a fragment and examine it, if I may be allowed the expression, microscopically, then we find it not to be continuous, but composed of minor changes.

The neighbourhood is, indeed, classical ground for the geologist, and in the works of Lyell may be found a wonderfully clear description of the geology, largely from his own observation. The oldest beds mentioned are those of the island of Ischia, and you will see on the table a small collection of shells from this island. The oldest are those from the Mount Buceto district, although these are the results from several localities and from more than one visit there is not a single species there which I do not possess in my collection of recent shells from Naples, and this is an important fact as showing that the common fossils, at any rate, are the same species as those now living and common.

* Lyell, in the list he gives, says his fossils were from the various fossiliferous localities of the island, which are now known to be of different ages. † Sig. Fonseca gives the following list from the Mount Buceto beds:—

Nassa prismatica	Cassis undulata
Solen coarctus	Turritella communis
Rissoa polita	Nucula sulcata
Natica sordida	Murex vaginatus
„ Valenciennesii	Fusus rostatus

To these I am able to add

Cardium ciliare	Trochus crenulatus Brocc.
„ echinatum Linn	„ exasperatus Penn.
„ edule L.	Cerithium reticulatum
Nassa Ascanias Brug	Phasianella pulla L.
Rissoa cimex L.	Dentalium entalis L.

The rocks of this neighbourhood are very largely composed of the tuffs of various volcanoes, as our President pointed out a few weeks ago, when I took the opportunity of saying that the large areas they cover and to what great thickness they occur is not readily appreciated by those who have not seen them. The peninsula of Sorrento is composed

* Principles of Geology, ed. 1, 1833, vol. 3.

† Geologia della Isola d'Ischia, per F. Fonseca. 1870. Firenze: Tip Cavour.

See also Monografia geologica dell' Isola d'Ischia, per C. W. C. Fuchs. Mem. del R. Comit Geologico, vol. 2.

principally of a tuff, as is the nucleus of the island of Ischia, and these two will be the oldest in the district. The tuffs of Sorrento have been for some time considered to be of a different age from those of the Phlegrean fields, and are supposed to be derived from eruptions of the Rocca monfina, an ancient volcanic mountain about forty miles distant. Although I have seen this tuff I have not made any examination as to its age, so that I cannot say if it is the same as any on Mount Epomeo, in Ischia, which is also older than the Campi Phlegraei.

This tuff in Ischia, which is the product of decomposed pumice and scoria deposited in the sea, has been raised to the height of 2407 Paris feet, and upon the sides of the mountain overlaying this tuff is a clay deposit which contains shells, as at Monte Buceto (1161 feet) and other places up to a height of about 1800 feet, and is a deposit of great thickness.

This clay lithologically much resembles the Sub-apennines, but the fossils indicate that it is much more recent,* so that apparently, at the close of the Pliocene, the whole of this neighbourhood was under the sea, and then by scoria and pumice, which floated a long distance, a deposit of many hundred feet thick (1000 in Ischia, according to Fuchs) was formed, upon which some hundred feet of a fossiliferous clay, with the fossils just mentioned, were deposited; then came eruptions, at first under water; then elevation and a constant succession of eruptions, for there are evidences of many eruptions here, and it is interesting to see in the cliffs on the shore layer above layer of lava, and volcanic cones scattered round this lovely island.

The volcanic activity has continued into the historical

* I hoped that a microscopical examination might aid in fixing the age more exactly, but M. Vanden Broeck, to whom I gave some of the clay, says that he has not been able to find any trace of either foraminifera or entomostraca.

period, but anyone who examines these lavas, some of which are interstratified with marine deposits, must feel how comparatively little these few historical eruptions have added to the volcanic mass of the island.

There are two other fossiliferous deposits on the island of Ischia; one is in a sandy marne at * Castiglione, &c., and is previous to several ancient eruptions; the other is a modern-looking lava-sand, which reaches at † Lacco to 200 to 300 feet above the level of the sea. From this last locality the number of species is considerable, but the same as those now in the neighbouring seas.

A few fossils have also been found in a tuff at Camaldoli, which is somewhat similar to that of Ischia, and at ‡ Pozzuoli there is a fossiliferous fine sand, somewhat resembling loess, interstratified with tuff and lava, but these fossils are similar in species and frequency to those inhabiting the Bay of Naples.

But in this neighbourhood, where such clear signs of such very recent changes on a large scale are visible, there are also the records of changes of level since buildings were erected, but we now come down from changes of some thousands to 30—40 feet in more than two thousand years, and here again the changes have not been continuous in one direction, but have been both elevation and subsidence.

The changes here are not general for all of Italy, as the examination of other § Mediterranean ports prove, but are more or less local. Different places in this neighbourhood,

* I found the following fossils, which are not given by Fonseca in his list, *loc. cit.*:—Pectunculus glycimeris, Chama gryphoides. Echinocyamus pusillus, Cyclope neritea L. Ringuicula auriculata Men.

† The additions here are:—Astarte incrassata Brocc. Echinocyamus pusillus, Fusus rostratus ? Cyclope neritoides, Cardita aculeata.

‡ Contribuzione alla geologica dei Campi Flegrei par G. Guiscardi. Atti Accad. Sci. I. 1863, No. 7.

§ I have not been able to verify this myself, but give it on the best authority, viz., Lyell.

as Bajae, Pozzuoli, Sorrento, Capri, show that within a very recent period the land has been elevated 20—30 feet.

Along a great part of the coast by Pozzuoli there is an abrupt cliff or tuff, and any Geologist can at once see that the cliff separated by the level Starza from the present shore has been washed by the Mediterranean sea, the present configuration being the consequence of this. The occurrence of barnacles and Arca, and the borings of Lithodomus, at 32 feet above the level of the sea, where there is a line worn by the waves, indicates the amount of change at a very recent period. In this terrace of stratified deposit, which reaches up to the cliff, and is here called the Starza, shells

are also found, but as we have seen no difference in deposits older than the present, of course none are found here, but in this are fragments of brick as it of such a recent date.

In the immediate neighbourhood of the Starza there are still other records, but one which has been the subject of full scientific description, first by Goethe, and now known to everyone by Sir Chas. Lyell's writings, but although so well-known a short recapitulation of the facts will enable us the better to understand the changes.*

At Pozzuoli, in the year 1750, the ruins of a fine so-called temple or bath were unearthed, a number of large columns of marble were discovered, and those parts which had been

* For full description of the changes see also Babbage, Geol. Soc. Proc., 1834.

the lowest when standing were all bored by the same shell, which I have mentioned the lithodomus, and these borings occur up to a height of 20 feet, above which the pillars did not show any traces of the action of the sea or marine animals. This shows the sea must, at some time, have here been at a height of twenty feet above the base of the pillars, and there are various indications—which space prevents my considering at present—which show that the subsidence, which brought about this state of things, took place slowly. This so-called temple of Serapis was built more than a century before Christ, and already before the end of the second century some subsidence had taken place, for it became necessary to construct a new floor. After this the temple was filled with volcanic ash from a neighbouring eruption. By the commencement of the fifteenth century the period of elevation had again begun, and the land in the district has been elevated about 20 feet, and again during the present century there has been considerable subsidence. There are many other buildings indicating these changes in the vicinity, but perhaps none where the record is more complete, and although not general over all Italy, extended over a considerable area round Naples.

In Sicily, movements within the historical period are also proved, but here upon the production of nature. *Sig. G. G. Gemellaro has shown that a lava of A.D. 1169 has been nearly a metre lower than at present, relatively to the sea, as proved by recent shell borings, and by the existence of shells forming almost a raised beach at this height. He concludes by the presence of quite recent deposits, that there has been a subsidence of 13 metres when a reversal of movement took place, not of course within historical periods, but very recently. Raised shore lines have also been found in

* Sul graduale sollevamento di una parte della costa di Sicilia. Atti dell' Accademia Gioenia di Sc. Nat. ser 2, tom XIV.

Corsica and Sardinia, Gibraltar, Tunis, Greece, and Asia Minor; the amount of quite recent elevations being apparently greater in Greece and Asia Minor than in the Western part of the Mediterranean, as proved by the position of Ephesus and Priene; and what is a matter of greatest interest to the owners of the Suez Canal, not only as concerning the past, but also commercially the future, is that according to M. Lesseps, there has been an elevation of three and a half metres in eleven centuries, and this, I may say, in a district where there are also proofs of most recent subsidences.

Recent movements are in no way confined to the volcanic regions of Naples—or other volcanic regions—as sometimes supposed. Recent changes of level to a large extent are known to have taken place in England, Scandinavia, South America, New Zealand, and Australia.

Having considered the changes of level of land in recent geological and historical periods, we may glance at the eruptions of the district of Naples. The trachytic tuffs, which have been raised to form Mount Epomeo (795 metres) in Ischia, and which forms the Posilipo and the Hill of Camaldoli, and other hills by Naples, show that there has been very considerable volcanic activity at this late geological period, many eruptions having occurred in Ischia and the Phlegrean fields, and after the greater part of these Vesuvius has been built up to a mountain 4000 feet high. The accounts of the mountain previous to the great eruption of A.D. 79, which destroyed Pompeii, show that it was then much higher, as it would appear that Monte Somma formed part of the great cone of the mountain, but at the time of the greatest eruption the old cone was destroyed, and the present Vesuvius was formed.*

Nearly sixty times since the Christian era Vesuvius is

* For a full account of Vesuvius see Phillips' Vesuvius. Oxford, 1869.

known to have been in a state of activity, and has poured forth streams of lava; previous to this it seems to have been in a state of tranquility, but had been recognised as of volcanic origin by some of the earliest historians, who relate that according to tradition it had emitted fire in earlier times. Since the earliest records several towns have been buried by lava and ashes. Pompeii, four miles from the cone, by a layer of ten to twenty feet of ashes. Herculaneum, about the same distance, by 70 to 110 feet of lava and ashes; the result of six eruptions being there visible in some places, and by Resina and Portici there have been many streams of lava, which have had a very considerable thickness. In many eruptions the ashes have fallen in Naples and neighbouring places in considerable quantities. In the last eruption, in the island of Ischia, 23 miles from the cone, the ashes which fell had to be swept up constantly near to the houses. In A.D. 472 an eruption is reported to have occurred which covered all Europe with fine ashes, and spread alarm even at Constantinople, and in 1779 small stones and scoria fell at Benevento, Foggia, and Monte Mileto.

In the Campi Phlegraei there are many craters, most of which have been formed previous to historical records, but the eruption in which Monte Nuovo was built up to a height of 139 metres in three or four days was in the 16th century. In the 12th century there was an eruption of the Solfatara, which has been since quiescent.

In Italy there have been regions of volcanic activity during the tertiary period, which have long since become dormant. With one exception all these districts are on the West side of the Apennines, but for a long time during the Eocene and lower Miocene, the neighbourhood of the Vicentine was the theatre of a succession of eruptions on a very large scale. A great part of these were submarine, and in

the volcanic tuffs, in many places, fossils are found in abundance, thus fixing the age and showing that there were many eruptions. In the district of the lake of Garda there were a number of lava flows; mostly at the beginning of this volcanic activity, while in the Vicentine and Euganean hills, are found the closing chapters of this disturbance. If time had permitted I should have liked to have shown how this neighbourhood, which I have visited several times, gives proof of constant changes of level in the Eocene and lower Miocene, not less instructive than those of the Pliocene of the South.

As the district belongs geologically to the Alps rather than to Italy, we may say that all Italian volcanoes are on the East of the Apennines, and they have been placed in the following chronological order by M. L. Pilla :—1. Ponza Islands, with Panaria, San Paolo in Mount Vultur. 2. Val di Nota, Cap Passaro. 3. Rocca Monfina. 4. Phlegrean fields, Eolian Isles, Vultur. 5. Vesuvius, Etna, Stromboli. 6 Monte Nuovo.

The Apennines are the central elevation of Italy, consisting of Jurassic, Cretaceous, and Eocene rock, with subsidiary mountain chains on both sides of the principal ridge, but as *Sir Roderick Murchison has pointed out "the Italian peninsula is not characterised by one central backbone or central axis," but instead the mountain chain "is made up of a succession of axes." Thus we see that the Apennines have been raised by various local upheavals and not in one line, and the same thing has been indicated with regard to the general elevation of the land. The same is the case to a certain extent in the Alps, for the Westerm were raised before the Eastern.

I mention this because it seems to be very generally considered that continental elevation takes place somewhat in

* Murchison on the Structure of the Alps. Proc. Geol. Soc., vol V. 1849.

the same steady regular manner that a trunk is raised upon an hotel lift, and that in the same way a mountain is gradually raised along its whole length, in one steady motion. I think we may well doubt if continental elevation of this kind has ever taken place; and we often see that the direction of elevation may change from North and South to East and West, as may be seen in the Miocene of North Europe. Of course the general tendency of the movements may continue for a long time in one direction, as seen in the Pliocene of Italy. In the Messinian and Astian periods the North of Italy shows that there was constant alteration of direction, and the uppermost Pliocene of Sicily that there there was movement sometimes up and sometimes down; but nevertheless through the whole there has been a general elevation of the Italian peninsula.

In geological text books we frequently find the thickness of the strata in different systems stated, and the relative age is calculated upon this basis. For the thickness of the tertiary 3000 feet is given, but this produces a wrong idea as to the age, for we must separate the various stages and see what is the total thickness. If the total is merely taken at any place much is left out; for example, while more than 100 feet of deposit representing a long period was formed in the South of Italy and Sicily, the north was land and no deposit could be formed. The total of the different stages as given by Dr. C. Mayer is about 28,000 feet—all deposited at different eras—instead of 3000 feet, and I think if this table were revised he would make it, if anything, rather greater. But taking the upper 500 metres, viz., 300 Messinian and 200 Astian, for the formation of 300 metres of Messinian there must have been a subsidence of about 2000 feet, and of course a like elevation by the close of the Astian, that the minimum amount of movement must have been 4000 feet.

Having learnt that this was not a steady movement, but oscillation, we see that this 4000 feet very imperfectly represents the amount of elevation and subsidence in these two periods, being probably many times as great as indicated by the geological phenomena. The changes at Naples and other places justify us in concluding that there must have been many minute variations, and that the number obtained by geological evidence may require to be multiplied many times to give a correct idea of the total amount of alteration.

That such great changes cannot be taking place all over the crust of the earth without altering the position of the centre of gravity must be apparent to all, and every alteration must change the position of the axis of the earth, unless the alteration should happen to be along the line of the equator.

It must be a matter of the greatest satisfaction to all geologists, that latterly the mathematicians [redacted]

* Page 279. Remarks on the Recent Geology of Italy. (Trans. Manchester Geol. Soc. June, 1877.)

Prof. Haughton has kindly informed me that he has found a mistake in this formula, as he omitted to divide by 3 when differentiating problem 8 of his paper.

The formula now stands $r\theta = -\frac{14{\cdot}11}{3}(\cos^{-1}\lambda' - \cos^{-1}\lambda)$.

This I am sorry to say makes the figures in the last paragraph of page 279 and the first of page 280 incorrect, and all the figures representing the amount of shifting of the pole should be divided by 3. Thus

instead of	141	read	$\frac{141}{3} = 47$
,,	1128	,,	$\frac{1128}{3}$
,,	2820	,,	$\frac{2820}{3}$
,,	7050	,,	$\frac{7050}{3}$
,,	7000	,,	$\frac{7000}{3}$

The scale to the curve should now be [illegible]

the solid earth to 1000 feet above [illegible]
lowest and highest degrees of latitude on each meridian.

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It must be a matter of the greatest satisfaction to all geologists, that latterly the mathematicians are giving their attention to this interesting subject. They have shown exactly how much sinking or rising would be necessary to produce given effects, but when the ultimate amount of change since the Eocene is considered it is found insufficient to account for such a change of position of the poles as is required to explain the luxuriant flora which existed north of 80° lat.

I have calculated the amount which an elevation of Sicily to the height of 500 feet would produce. Using the formula given by * Prof. Haughton in a paper to the Royal Society, we find that such an elevation would move the pole 141 feet towards Behring's Strait, but the total shifting which would be caused by the movements of the 4000 feet just mentioned

* Notes on Physical Geology, by the Rev. S. Haughton, M.A., F.R.S. &c. Proc. of Royal Society, vol. xxvi. 1877, March 8th, an abstract is given in Nature, April 19th, 1877. The formula is $r\,\theta = -14{\cdot}11\ (\cos^3\lambda' - \cos^3\lambda)$ $r\,\theta =$ the distance in miles that the axis would be moved by an elevation of an area of 5 degrees of longitude from the original surface of the solid earth to 1000 feet above the mean sea level, λ and λ' being the lowest and highest degrees of latitude on each meridian.

would instead be 1128 feet, but any movement of the dry land also represents a movement of its share of the submarine land, and as the proportion of the sea to the land is about as 5 to 2, this would leave a shifting of 2820 feet caused by the movements traced in this small island of Sicily, in the Messinian and Astian periods.

The Pleistocene gives another 4230 feet, in all 7050 feet or rather more than a mile and a quarter of shifting backwards and forwards since the Miocene, so that the 141 feet of ultimate change (taking the elevation as 500 feet, or if 1000 feet is taken 282 feet) represents oscillations of the pole of at any rate over 7000 feet, probably many times more.

The astronomers have not at present found any indications of a change of position of the axis, since the time when their more exact observations enable them to judge, but it must not be forgotten how very small the changes are that would be produced by such alterations as we know to have taken place since the commencement of the historical period, for although the raising of a small continent would alter the position of the poles several miles, the raising of a small part a few feet would have a very slight effect. For instance, the elevation of Vesuvius from the sea level to its present height of 4000 feet would only change the position of the poles a little more than *one two thousandth part of an inch. The elevation of Etna would move it about $\frac{1}{1000}$ of an inch, and the Chili earthquake would have about the same effect, so that the astronomers may be let off without much blame if they do not discover such changes as there is reason to believe have taken place in the scientific period.

Perhaps no observation is more important in its bearing

* The formula used is: — $\tan 2\theta = 935.6\ \rho \sin 2\lambda$, as given by Prof. Haughton, *loc. cit.* θ = the displacement of the axis; ρ = the ratio of the weight of an elevated mass to the weight of the whole earth; λ = latitude.

on cosmical phenomena than that of an eclipse in Babylon in 721 B.C., and by that it is found that the earth is now rotating *11½ seconds a year slower than it did then. This the astronomers have put down to the tidal retardation which of course must have a constant effect, and I suppose it could be easily calculated if the quantity of water on the globe and its position were known, but as we have even yet much to learn about the ocean in warm and temperate regions and know nothing about the amount and what is in a movable state at the poles, it is quite impossible that this question could yield to calculation even were the form of the earth exactly known.

The influence of changes of level of the land seem to me certainly worthy of as much consideration as tidal retardation. Prof. Thomson points out that Prof. Newcomb has shown that this loss does not seem to be uniform at present, as the earth was going slower from 1850 to 1862 and faster from 1862 to 1872. Might not such changes be partly accounted for by the elevations and subsidences believed to be always taking place?

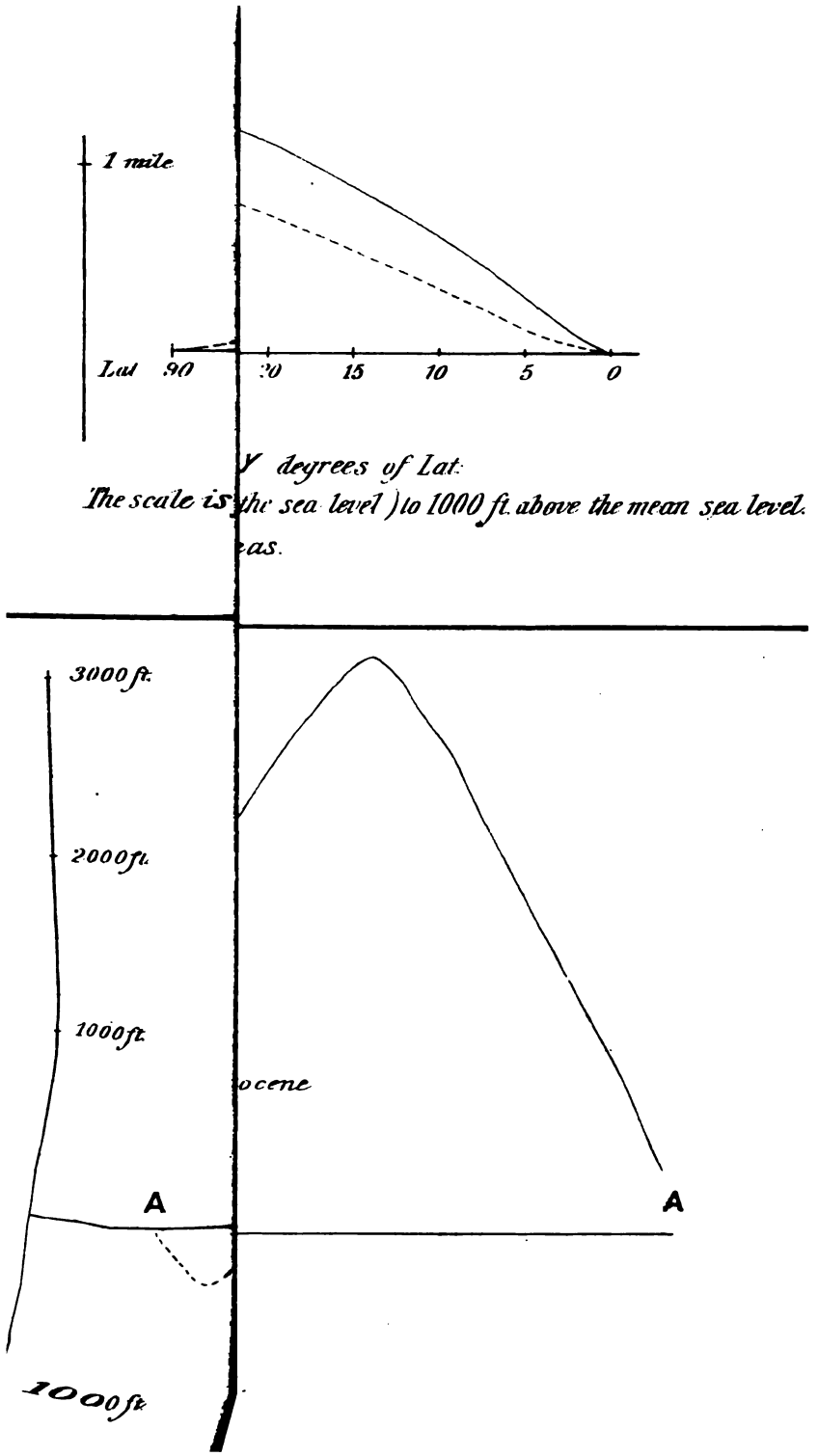
Although the changes during historical times are comparatively insignificant, when we look a little further back they are found to be very great. Since the beginning of the Miocene, the greater part of Europe, and Asia, and North Africa has been raised above the sea; and the amount of land between North America and Europe has during part of that time been much greater than at present. The geographical distribution of animals shows that, in this time, the Indian Ocean has much increased by the subsidence of parts of large continental areas, for Australia has been much more extensive, and many have considered there is evidence of an Indo-African connection, but the amount of

* Address of Sir William Thomson to the Physical Section of the British Association, 1876.

displacement caused by such an elevation as that of Asia is but small, being about 19 miles for an elevation of 1000 feet, and a sinking in the central India Ocean would move the poles in the same direction as the Asiatic elevation.

It would very frequently happen that the forces at work in one quarter balance those in another, and this would more often be the case if the distribution of land and sea was more symmetrical than at present, as then the shifting of the water would have less effect than now, for this in certain parts and under certain conditions may be a more powerful disturbing agent than the simple elevation of land, and moreover the elevation or subsidence of equal areas in different latitudes gives very different results, so that if a band of elevation in the 40th latitude was adjusted by an equal band of subsidence in the 20th, the permanent result would be about one-half of that of the elevation alone. The curve, No. 1, shows the amount of displacement produced by an elevation of an area of five degrees of longitude and the same number of degrees of latitude, for various latitudes, worked out by the formula given in page 29. The amount of elevation is from the normal surface to 1000 feet above the sea level. All these calculations are based upon a perfectly solid earth, but should a fluid interior be allowed, then of course the displacement would be much greater.

The whole question partly depends on whether the earth is sufficiently yielding, so that it can take a fresh figure of rotation when the axis is shifted, but knowing that it has been able to bob up and down so frequently in Italy and elsewhere, and to such great extent, we may surely conclude that the enormous centrifugal force will soon tend to make the equatorial bulge symmetrical, and that the approximate figure of rotation would be brought about in whatever position the earth was placed.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OLD OAK TREES.

Mr. E. W. Binney wished to call the attention of the members to a Paper by him "On the Geology of Manchester and its Neighbourhood," printed in Vol. III., p. 355, of the Transactions of the Society, which those present at the last meeting, when a communication "On Old Trees in the Bed of the Irwell at Brooksbottom," by the Rev. Addison Crofton, M.A., was read, appear not to have been acquainted with. After describing at length the valley gravels near Manchester, and discussing their origin, he said: I observed another section, lately made in Lockett Street, Strangeways. In the cutting of a sewer down to twenty feet—about the level of the river (Irwell)—the workmen there cut through beds of gravel, sand, and silt, and a large oak tree lay at the bottom of the sewer, by which their operations were a good deal inconvenienced. At the Gaythorn Gas Works, some years since, after cutting through sand, silt, and valley gravel, the workmen found large oak trees at the bottom of this gravel, one of which was four or five feet in diameter. The trees at Gaythorn, in the valley of the Medlock, Manchester, are fully described in Vol. VIII., p. 210, of the Memoirs of the Literary and Philosophical Society. In the first-named Paper he shows the changes that have taken place in the course of the Irwell, in the valley gravel at Broughton, in modern times, and suggested that the old plans belonging to the Broughton estate, if they could be seen, would probably give the rate of such change.

REMARKS UPON A FLINT ARROW TIP AND SOME FLINT FLAKES

FOUND IN THE NEIGHBOURHOOD OF BACUP, ALSO UPON SOME STONE IMPLEMENTS RECENTLY DISCOVERED AT LAND'S END, CORNWALL, AND OTHER PLACES,

By Mr. John Aitken, F.G.S.

It may be remembered that in the course of a short paper contributed to this Society on the 30th of June, 1874, "On the occurrence of High Level Drift in the Neighbourhood of Bacup," I exhibited and referred to two flint flakes which I had obtained from the summit of Bull Hill, and at the same time pointed out that from their form and general character, no doubt could be entertained that they had been produced by artificial means. Since that time further investigation at the same place has resulted in the discovery of some fifty or sixty flakes and chips, together with an arrow tip and a flint core, the number of small fragments at one spot being so great as to lead to the inference that a manufactory of flint weapons had been carried on there. The finding of worked flints in this position suggested the probability that a diligent search would reveal others in similar situations in the neighbourhood, and I have now the satisfaction of announcing that through the exertions of a number of observers, worked flints have already been discovered in three or four additonal places, the most interesting discovery, however, occurring at Tooter Hill, an elevated and prominent summit of the Pennine Range, about two miles east of Bacup, where, in addition to a number of flint flakes of the usual type, a true-worked and well-formed arrow tip has been picked up, from which, however, the

point has unfortunately been broken, either from having been used or more probably by fracture in the course of manufacture, and consequently rejected as useless at the time.*

The discovery of this worked arrow tip is important, as placing beyond doubt the fact not only that man was an inhabitant of these districts in pre-historic times, but that he also made use of flint for the fabrication of his weapons, the finding of which, I trust, will have the effect of completely removing any lingering doubt which may still remain upon the mind of even the most sceptical, as to the artificial nature of these chipped flints. It is found, now that attention is being more and more directed to this branch of investigation, that these ancient memorials of man's existence are much more widely distributed than was at one time supposed, for not only have they been found in association with his bones in places of sepulture, and in caves and rock shelters, but also more recently on many of the hills of Lancashire, Derbyshire, Yorkshire, Northumberland, and other places, where the physical features are favorable for their detection, and where sufficiently accurate investigation has taken place. Flint in an unworked state is, as has been pointed out on previous occasions, exceedingly scarce in this part of Lancashire, the material for the fabrication of these implements must, therefore, have been introduced by man for the purpose of being worked up by him, and thus made to minister to his wants and conveniences.

In addition to the foregoing notice, I desire also to call the attention of the Society to a number of flakes and other worked stones I have recently met with at Land's End, in

* Mr. Thomas Aitken and myself have found flint flakes at Broadclouhg Shepherd's Height, Dirpley, and Tooter Hill, in the neighbourhood of Bacup, and the first-named gentleman was also the fortunate discoverer of the worked arrow tip referred to.

Cornwall, and also upon an eminence situated between the east and west branches of the River Allen, about 2 miles west of Allendale town, in the county of Northumberland. In the former instance (viz., at Land's End) the find consists of about twenty pieces of flint and one of quartz—seventeen being of the ordinary type of flint flakes and chips, one a small flint-core, one a portion of a core, which appears to have been used as a "strike-a-light," and one a chipped quartz crystal, worked—although somewhat rudely—into the form of a spear, or javelin point. They were found exposed in a section at the side of a small ravine, about one mile south of Land's End Hotel, lying beneath about a foot of surface soil, upon a matrix of decomposed granite several feet in thickness. And in the latter instance (viz., Allandale), I found in about two hours from twenty to thirty flint-flakes and chips, and one beautifully-formed arrow tip, and many others have been collected during the last twelve months at the same spot.* The occurrence of worked flints in Cornwall is the more remarkable, seeing that no flint from which they could have been made is found in *situ* nearer than the county of Dorset, at a distance of some 220 miles to the N.E., nor yet could the material have been derived from the drift [as in some instances further to the north], as no deposit of this character is with certainty known to exist in this or the adjoining county of Devon; and the same remark applies, with but slight variation, to the Northumberland site, for there, although drift exists in considerable quantities, flint, I am informed, is altogether unknown in the district.

The occurrence of chipped flints in Cornwall has been known for several years past, and attention has been drawn

* A few days before I visited the spot, the Rev. W. Howchin, of Haltwhistle, secured twenty or thirty flint flakes, three very perfect arrow tips, and two portions of a polished green stone celt or hatchet.

to the fact on more than one occasion; amongst others by Mr. N. Whitley, C.E., Hon. Sec. of the Royal Institution of Cornwall, who, in a series of papers read before that Society in 1875, after describing a number of places in which flint flakes and other "so-called" worked stones had been found in the counties of Devon and Cornwall, contended at great length that, from their occurrence in such considerable numbers, the wide extent of their distribution, and their capability of being produced by the simple operations of nature, their origin was to be attributed to this cause, rather than to artificial means. I conceive, however, notwithstanding the ability and ingenuity with which Mr. Whitley advocates his views, that if we fairly and impartially examine and weigh the evidence *pro* and *con*, inspect the specimens themselves, and consider the difficulty of accounting for the presence of flint in these out-of-the-way districts, taken in conjunction with the overwhelming concurrence of testimony on the part of those who have given special attention to this subject, we shall experience no difficulty in declining to be guided by Mr. Whitley's reasoning, nor yet in coming to the conclusion that they are really and truly works of art, and that their presence in the situations, and under the conditions named, enable us to speculate with more probability than by any other evidence which has come down to us, as to man's social state, and the conditions under which he existed in those remote and far-off periods of time in the world's history.

SPECIMENS EXHIBITED ILLUSTRATING THE FOREGOING PAPER.

By Mr. John Aitken.

No. 1. Arrow tip (fractured) and three flint flakes, No. 2 showing bulb of concussion. Tooter Hill, Bacup.

No. 2. Chert flake. Shepherd's Height, Bacup.

No. 3. One flint flake. Brandwood Moor, Bacup.

No. 4. Four flint flakes. Broadclough, Bacup.

No. 5. Chipped flint. Dirpley Hill, near Bacup.

No. 6. Six flint flakes. Land's End, Cornwall. No. 3 showing bulb of concussion.

No. 7. Flint core. Land's End, Cornwall.

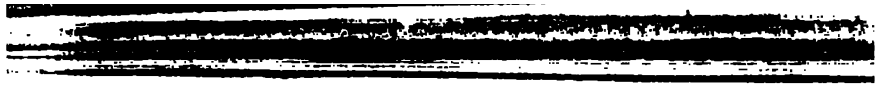
No. 8. Flint "Strike-a-light." Land's End, Cornwall.

No. 9. Chipped quartz crystal, probably intended for a spear head. **Land's End, Cornwall.**

No. 10. One arrow tip and seven flint flakes. Bull Hill, near Ramsbottom.

No. 11. Flint core. Bull Hill, near Ramsbottom.

No. 12. One very perfect arrow tip, five flint flakes, No. 2 showing bulb of concussion, and one scraper worn smooth by use. Hill above Allendale town, Northumberland.



TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIV. VOL. XIV. SESSION 1877–8.

ANNUAL MEETING.

The ANNUAL MEETING of the Members of the Society was held on Tuesday, the 30th October, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

Professor W. BOYD DAWKINS, F.R.S., President, in the Chair.

Mr. Daniel Adamson, F.G.S., The Towers, Didsbury; Mr. David Arthur, Baxenden Collieries, near Accrington; Mr. James Atherton, 16, Acresfield, Bolton; Mr. Lewis Jackson, Rocher Colliery, Ashton-under-Lyne; Mr. Maskell W. Peace, Wigan; Mr. George Robins, Ashton, near Newton-le-Willows; Sir Ughtred Kay-Shuttleworth, Bart., M.P., Gawthorpe Hall, Burnley; Mr. James Smallshaw, Westleigh, near Manchester; Mr. Joseph Wild, Smithfold Colliery, Little Hulton; and Mr. Harold George Wheeler, The Cockey Moor Colliery Company, Radcliffe, were elected ordinary members of the Society.

ON THE ANTIQUITY OF MAN.

By W. Boyd Dawkins, M.A., F.R.S.

1. *The Coal Measures of the South-East of England.*
2. *The Antiquity of Man.*
   - (*a.*) *The Creswell Cave Exploration.*
   - (*b.*) *Cave-Man probably an Eskimo.*
   - (*c.*) *Northern and Southern Animals in Cave-fauna lived together.*
   - (*d.*) *Man here in late Pleistocene times.*
   - (*e.*) *Evidence of Man in the Pleistocene stratum in Victoria Cave unsatisfactory.*
   - (*f.*) *No Proof of Interglacial Man in Britain.*
   - (*g.*) *Nor in Switzerland.*
   - (*h.*) *Oldest strata with implements in Britain.*
   - (*i.*) *Man probably pre-post and inter-glacial in Europe.*
   - (*k.*) *Glacial Period not a standard.*
   - (*l.*) *The asserted Pleiocene Man of Denise.*
   - (*m.*) *The Human Skull at Olmo.*
   - (*n.*) *The Cut-bones of Tuscany.*
   - (*o.*) *The asserted Miocene Man of Thenay.*
   - (*p.*) *Antiquity of Man not measurable in term of years.*
   - (*q.*) *Never-the-less vast.*
   - (*r.*) *Conclusion.*

I. The Coal Measures of the South of England.

In taking stock, to borrow a mercantile term, of the net results of geological and palaeontological enquiry during the last session, we have to remark that the additions to our knowledge have consisted in detail rather than in the discovery of great principles, and that the ground already conquered from the region of the unknown has been resurveyed and more minutely parcelled up, instead of being increased by large slices of territory. The most important discovery which concerns us in Manchester is that of the Devonian rocks underneath London, met with in Messrs. Meux's deep-sinking for water, at a depth of 1073 feet. This not only verifies a similar discovery years ago in Kentish Town, but it proves, by the high angle at which the strata dip, that the primary land-surface under the secondary rocks in that district is thrown

into a series of folds, as is the case in Belgium and Somersetshire, and that in the neighbourhood of the metropolis there is evidence of coal-fields, analogous to those of the regions above mentioned, and probably at a workable depth. There is every reason to believe that eventually these will be discovered, and a change brought about by which centres of manufacture will be established in the south of England, similar to that which has taken place in Lancashire. These two borings offer a base-line, so to speak, for the discovery of the coal-fields in the south of England, which has hitherto been wanting. It must be remembered that down to the middle ages Kent and Sussex were the home of the iron trade, while the forests afforded fuel for smelting, and that therefore the establishment of manufactures based upon the production of coal would merely be a return of commercial industry to its ancient seats—one of the many instances of a tendency in things to repeat themselves.

2. The Antiquity of Man.

(*a.*) *The Creswell Cave Exploration.*

I turn from this practical matter, which is worthy of the attention of enlightened statesmanship, to a question which has been very prominently brought forward during the last year, the antiquity of man. The recent discoveries in the caves of Creswell Crags,* on the borders of Nottinghamshire and Derbyshire, have not only proved that man lived in the hunter stage of civilization in the valley of the Trent and its tributaries, along with the mammoth, woolly rhinoceros, cave hyæna, bear, lion, and reindeer and other creatures, but that he presents traces of a progress in knowledge. In the lowest stratum in these caves implements of the rudest and roughest form, made of quartzite pebbles from the neighbouring permian conglomerate, were the only tools left

* Quart. Geol. Journ. Lond., Aug., 1877, p. 581.

behind by the hunter. In the middle stratum, composed of red earth, he used better implements of flint, brought from a distance, while in the upper portion of the cave earth and in the breccia all his cutting implements were made of flint, and are of a higher order. During this period also, he used bone needles and various implements of bone and antler, and has left behind remarkable proof of his artistic skill in the figure of a horse engraved on a fragment of rib (on the table). This sequence establishes the fact, that even in the palæolithic age the hunters of reindeer, horse, mammoth and other creatures were progressive, and that the cave dwellers of the pleistocene age are to be looked upon from the same point of view as mankind at the present time, as "one man always living and incessantly learning." Among other additions made by these caves to the fauna of the north of England is that of the great sabre-toothed feline, *Machairodus latidens*, which hitherto has only been met with in two caverns, in Kent's Hole, in Devonshire, and the cave of Baume, in the Jura.

(*b.*) *Cave man probably an Eskimos.*

The figure of the horse is identical in design with those left behind by the hunters of reindeer in the caves of Auvergne and of Thayingen, and therefore proves that the inhabitants of the Creswell caves, during the time that the upper stratum was being accumulated, were in the same stage of artistic culture as the cave-dwellers of southern France and of Switzerland. With regard to the question who was he? the conclusion at which I arrived in 1866,* from the discoveries in the caves of France, that he is represented at the present time by the Eskimos, is strengthened by the whole body of facts made known since that time. Nevertheless it must be viewed as a probable hypothesis rather than as a well ascertained fact.

* *Saturday Review*, Dec. 8.

(c.) *Northern and Southern Animals in Cave-fauna lived together.*

The fauna by which the palæolithic hunter was surrounded was composed of a singular mixture of northern and southern types. At Creswell, for example, we find that the hyænas, not distinguishable in species from the spotted hyæna of South Africa, preyed upon the reindeer, so characteristic now of cold regions, and in several bone caves, such as those of Kirkdale and the Victoria cave in Yorkshire, the hippopotamus is associated in the same ossiferous stratum with the reindeer, as is also the case in several river deposits. The only explanation which I can offer of this fact is, that in the pleistocene age the continent extended from northern Africa as far as the British Isles and the hundred fathom line, and that during the changes of season the northern and southern forms of life overlapped. The view held by Dr. James Geikie* and others, that the southern animals were here in a warm interglacial period, while the northern were here in a colder glacial age, is negatived not merely by the association of remains in the Creswell caves, but by a similar association of forms in nearly all caves extending from Yorkshire as far south as the Alps and Pyrenees. We may take the fact of the reindeer having formed a large share of the food of the hyæna in France, Germany, and Britain, as tolerably good proof that both lived in the same region at the same time.

(d.) *Man here in Late Pleistocene Times.*

The evidence, offered by all the caves in the area from the Alps and Pyrenees as far north as Derbyshire, is clear that palaeolithic man was living in Europe while large numbers of reindeer were living here, or in other words in the late pleistocene age, when the arctic animals were abundant.

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* "Ice Age."

[illegible] *Stratum of Victoria*

[illegible] competent authorities that [illegible] an earlier period than this, in [illegible] times, and the assertion is well [illegible] The case in which it is founded [illegible] in which the evidence of man's [illegible] fragment of a fibula and two cut [illegible] The former has been proved by the [illegible] of the Geological Society of [illegible] Institute to belong most [illegible] to be far too equivocal in its [illegible] any generalization. The latter [illegible] the British Museum, to be [illegible] same state of preservation as [illegible] pleistocene stratum. The cuts [illegible] have been made by the sharp [illegible]

[illegible] animal which hitherto has [illegible] and river deposits of [illegible]

age. If this improbability be admitted, and we believe that man is represented in the pleistocene fauna of the cave, the relation of that fauna to the glacial period in that spot is still a matter of dispute.

(*f.*) *No proof of Interglacial Man in Britain.*

Nor do we meet with indisputable proof of interglacial or preglacial man in any other stratum in this country or on the continent. The case, supposed to be decisive on the point, of the flint implements in the deposit at Brandon, published by Mr. Skertchley more than a year ago, still remains unverified, some high authorities, including Prof. Hughes and Mr. Bonney, believing that it belongs to the same post glacial period as the ordinary implement-bearing river strata.

(*g.*) *No proof of Interglacial Man in Switzerland.*

The proof that man was living in Switzerland in interglacial times* is in my opinion founded on insufficient data. It is based solely on four small pointed sticks, the largest of which is of the size and shape of a cigar, in the interglacial deposit at Dürnten, and considered by Professors Rütimeyer and Schwendauer to offer proof of the presence of man in those times, because they are rounded, pointed, and traversed by lines of fibre running at right angles to their long axes, supposed to be fossil basket-work. Last summer, on examining these specimens, thanks to the kindness of my friend, Prof. Rütimeyer, at Basle, I was struck by their resemblance to knots out of rotten pine trunks, in which a similar form is frequently to be observed. As the woody fibre of the trunk decays the hard resinous knots stand out in relief, and as they approach the central pith of the tree

* Archiv für Anthropologie, Aug. 1875, p. 133. Heer Primeval World of Switzerland, transl. by James Heywood, ii Appendix 1.—Quart. Geol. Journ., Aug. 1877, p. 611.

(e.) *No Evidence of Man in Pleistocene Stratum of Victoria Cave.*

It has been asserted by several competent authorities that we have evidence of man at an earlier period than this, in interglacial or preglacial times, and the assertion is well worthy of criticism. The first case on which it is founded is that of the Victoria cave, in which the evidence of man's presence consists of a fragment of a fibula and two cut fragments of bone. The former has been proved by the discussion in the last session of the Geological Society of London and the Anthropological Institute to belong most probably to the cave bear, and to be far too equivocal in its nature to form the basis of any generalization. The latter are considered by Mr. Davies, of the British Museum, to be recent bones, and not in the same state of preservation as as the fossil bones from the pleistocene stratum. The cuts upon them seem to me to have been made by the sharp edge of metal.

They belong to the goat, an animal which hitherto has been unknown in the Pleistocene caves and river deposits of Britain, and which is equally conspicuous by its absence from similar strata both in France and Switzerland, according to the experience of my friends Prof. Gaudry, of Paris, and Rütimeyer, of Basle.* Similar bones occur in abundance in the superficial layer in the Victoria cave, similarly cut and in the same recent state, and they might readily slip down on the working face and become imbedded in the clay at the bottom of the cutting. It seems, therefore, to me that they do not offer the kind of proof that is wanted. If, however, they be taken to be pleistocene, it must be allowed not only that the goat was then in Yorkshire, but also that metal-using peoples were present in the pleistocene

* This asserted discovery of goat in the Pleistocene strata in the caves of Belgium by M. Dupont has not been verified.

age. If this improbability be admitted, and we believe that man is represented in the pleistocene fauna of the cave, the relation of that fauna to the glacial period in that spot is still a matter of dispute.

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* Archiv für Anthropologie, Aug. 1875, p. 133. Heer Primeval World of Switzerland, transl. by James Heywood, ii Appendix 1.—Quart. Geol. Journ., Aug. 1877, p. 611.

taper to a point in the same way as these of Dürnten. They are, moreover, covered superficially by fibres of the trunk crossing those of the knots at right angles, or nearly so, precisely in the same way. The Dürnten specimens have been proved, by microscopical examination, to be composed of the wood of the red fir *(abies excelsa)*. Under these circumstances I have but little doubt of their being knots out of a decayed fir tree of interglacial age, and I believe them to present no sign whatever of the handiwork of man.

(*h.*) *Oldest Strata with Implements in Britain.*

The oldest deposit in this country which presents us with the traces of man is that of the lower brickearths of Crayford and Erith in Kent, which is characterised by a fauna intermediate between that of the forest bed and the ordinary post-glacial gravels, and in which the survival of the Pleiocene rhinoceros megarhinus is one of the important features. They consist of two flint flakes found in undisturbed strata, one by the Rev. Osman Fisher, and myself, in 1872, and the other by Mr. R. W. Cheadle, in 1876. Here again the precise relation to the glacial deposits is in dispute.

(*i.*) *Man probably pre-post, and inter-glacial in Europe.*

While, however, the interglacial or preglacial age of deposits with the traces of man is uncertain, there is every reason for the belief that palaeolithic man came into Europe along with the fauna, of which mammoths and reindeer were prominent members, and which were inhabitants of this country before the glacial period. I have little doubt but that he was living in middle and southern France, and it may be in this country also, while large masses of ice covered Scotland and the highlands of Lancashire and of Wales with huge confluent glaciers. That he lived in this country after the maximum glacial cold had passed away is proved by the implements in the post-glacial gravels of Hoxne and Bedford.

(*k.*) *The Glacial Period not a Standard.*

The glacial period itself does not present us with a hard and fast line, as is sometimes asserted. It does not divide one fauna from another, nor does it map off the Pleistocene series of events from the Pleiocene on the one hand or from the prehistoric on the other. It cannot therefore be considered as a standard by which to measure the antiquity of man, which can only be arrived at by the method invariably followed in geological research until within the last few years, by an appeal to the fauna and flora. By this latter standard the traces of man are proved to be late Pleistocene in every case except that of the lower brick earths of the Thames valley, because of the abundance of Arctic mammalia with which they are associated.

(*l.*) *The Asserted Pleiocene Man of Denise.*

The remains of man are asserted to occur in deposits of vastly higher antiquity than those considered above, in pleiocene and meiocene strata. A human skeleton found at Denise, near Le Puy, is stated to have been buried in volcanic ash, under conditions which showed that its possessor fell a victim to a volcanic eruption in the pleiocene age. It may, however, be an interment in a material in which it is extremely difficult to tell disturbed from undisturbed portions; or, as Sir Charles Lyell suggests, it may have been derived from a stratum newer than the pleiocene.

(*m.*) *The Human Skull at Olmo.*

The human skull found by Professor Cocchi in a railway cutting at Olmo, near Arezzo,* after a slip had occurred, and considered to be of pleiocene age, was probably derived from the slip. The flint implement found along with it, according to Mr. Evans, is of a well-known neolithic type, and proves that it may be of that vastly later period.

* Forsyth Major, Letta nell' Adunanza della Società Ital. di Anthropol. e di Etnolog. 20 April, 1876.

(n.) *The Cut Bones of Tuscany.*

Man is believed by Professor Capellini, of Bologna,* to have been living in Italy in the pleiocene age, from his discovery of numerous cut bones of a fossil whale in Tuscany. These cuts seem to me, when I had the opportunity of studying the evidence at Bologna, to be undoubtedly artificial, and to have been made before the mineralization of the fragments, one of them in particular being covered with an incrustation of sulphate of barytes. Along with them were flint flakes and a fragment of rude pottery. It is not, however, to my mind satisfactorily shown that these were obtained from undisturbed strata. Nor is the mineralization a proof of their high antiquity, since we know how rapidly deposits of sulphate of barytes have sometimes been formed in the wooden pipes of coal mines. There is an argument, however, against the probability of man having lived in Italy in pleiocene times that seems to me unanswerable. Twenty-one fossil mammalia have been recently proved by Dr. Major to have inhabited Tuscany in the pleiocene age: of these there is only one species, the hippopotamus, now alive on the earth. It is to my mind to the last degree improbable that man, the most highly specialised of the animal kingdom, should have been present in such a fauna as this, composed of so many extinct species. They belong to one stage of evolution, and man to another and a later stage.

(o.) *The Asserted Meiocene Man of Thenay.*

But if the difficulty of believing that man was living in Europe in the pleiocene age be great, from the rarity of living mammalian species, how much greater is the difficulty of accepting the asserted proof of the existence

* L'uomo Pliocenico Reale Acad. dei Lincei. 7 May, 1876.

of man in the remote ages of the meiocene, in which no living mammalia are known, from the discovery at Thenay of chipped flints in meiocene strata, by the Abbé Bourgeois. Some of the flints in question, which I have examined, have been chipped, while others—among which may be ranked a large number of those in the archaeological museum at St. Germains—appear to me natural. Some of the chipped ones are weathered in the same fashion as those on the surface in the neighbourhood. Altogether, they do not present us with a sufficient basis for the belief that man was living on the earth before any other mammalian species now alive had appeared, and surrounded by strange and weird animals such as the Deinotherium, belonging to extinct genera. I cannot resist the idea that there has been some mistake, by which worked flints from the surface have found their way into the collection of flints made from the meiocene strata below. The question is, however, one of simple evidence, which in this case does not carry conviction to my mind.

(*p.*) *Antiquity of Man not Measurable in Terms of Years.*

So far, then, as the evidence as to the antiquity of man goes we cannot trace it further back than the pleistocene age with any certainty. Nor, be it remarked, can we measure it in terms of years, by using the present rate of accumulation of sediment, or of stalagmite, or of the erosion of rock, as indices, because the rate is dependent on variable causes which cannot be assumed to have operated uniformly in past time. Nor, as it seems to me, do we gain any knowledge on the point from the assumption that the severe climate of the glacial period is due to a certain definite relation of the earth to the sun, recurrent at certain intervals capable of being computed by the mathematician. Is not the sun a variable star? Has not geographical change, as suggested by Lyell, a most important bearing on climate? In my opinion,

all attempts to compute past time by these methods are merely guesses founded on impossible or improbable assumptions. I would even say further, that any attempt to construct any chronology in terms of years outside the written documents of history must of necessity fail, because we do not know the length of the interval which separates any two events. The historical chronology is absolute; the geological merely relative. We know that the prehistoric succeeded the pleistocene age, but we cannot measure the interval in years.

(*q.*) *Nevertheless Vast.*

Nevertheless, when we consider the animals in Europe when man first appeared, and the series of geographical and climatal changes, as well as the successive appearance of different peoples, it is clear that the time when man first appeared in Europe is separated from our own day by a vast period, of which the years recorded by the historian are a small and insignificant fraction.

(*r.*) *Conclusion.*

I have now, gentlemen, fulfilled my task, which has consisted mainly in applying the test of criticism to the important geological problem of the antiquity of man. As time goes on the uncertain will become clear, and the faulty will drop out of memory, and ultimately we shall have the picture of man in the pleistocene age clearly presented to us—a picture to which the discoveries of the last few years have added a few master-strokes.

The following Report of the Council, and the Treasurer's Balance Sheet, were read by Mr. John E. Forbes, F.G.S., Honorary Secretary :—

REPORT OF THE COUNCIL FOR 1876-7.

In presenting their Thirty-eighth Annual Report your Council have pleasure in being able to record that the Session 1876-77 has been a successful and prosperous one. The meetings have been well attended and the number of members has been materially increased; the number on the register now being 144 as against 119 members at the same period last year. During the session three members have resigned and two are dead.

Interesting and valuable papers have been read and discussed at each of the ordinary meetings, and eight parts of the published Transactions have been circulated amongst the members and other societies with which publications are exchanged.

A field meeting was held, and an excursion, under the guidance of the President, has been made to the neighbourhood of Castleton, in Derbyshire.

The funds of the Society compare favourably with previous years. The outstanding subscriptions, with the exception of £14, have been all collected prior to the 1st instant, on which date the next year's subscription fell due. The balance due to the Hon. Treasurer has been reduced from £31 17s. 2d. to £11 17s. 0d., as shown by the accounts presented herewith, and the sum of £600 remains invested in the 4 per cent. Guaranteed Stock of the Chester and Birkenhead Railway, in the names of Henry Mere Ormerod and Andrew Knowles.

The Library has been augmented by the addition of several valuable works, but, as referred to in last year's

report, it continues a source of perplexity, owing to the space available for it being totally inadequate to allow of its arrangement in a suitable and useful manner. Its value is also very much impaired in consequence of the Society having no room at their disposal in which members can consult the works contained in the library. Your Council has had this matter under consideration for some time but has hitherto, in consequence of inadequate funds, been unable to decide upon any satisfactory arrangement by which this serious drawback would be overcome. Your Council, however, are of opinion that if the individual members would assist them, and increase the number of members by inducing their friends to join and subscribe to the Society, there would be little difficulty in supplying a want much felt by geologists and miners in this great centre of Lancashire industry, and one which in other similar industrial centres of this country has already been surmounted successfully.

In last year's report your Council drew attention to the unsatisfactory manner in which the authorities of The Owens College were dealing with the terms relating to admission to the Museum, contained in The Articles of Agreement by which they became possessed of this Society's collections. Your Council regret being unable to report to the members that the terms of the agreement have been complied with and published in The Owens College *Calendar* for the session 1877-78, but has pleasure in being in a position to announce that, in reply to communications which your Council directed the Honorary Secretaries to make to the Council of The Owens College, assurances have been received that it has been decided to open the Museum at once, in accordance with the terms of The Articles of Agreement, and that as soon as the detailed arrangements at present in course of completion by a sub-committee appointed for the purpose have been drawn up, the matter will be announced in the

local newspapers, and will be properly embodied in future publications of the *Calendar*.

Your Council will take steps to inform the members of the Society as to the details, as soon as they shall have received the official notification thereof.

The time fixed for holding the ordinary meetings of this Society during preceding sessions has given rise to many expressions of disappointment on the part of members unable to attend them. Your Council has had the matter under consideration, and should it be the wish of the meeting, would recommend that a trial of some other hour be made, on, say two days, in the ensuing session. The members present are requested to give an expression of opinion as to the time likely to be most convenient.

Your Council likewise solicit the co-operation of the members by contributing papers at the meetings, as it is only by the assistance of the members individually as well as collectively that the success of the Society can be attained.

It is with regret that the Council have to record the decease of two old and valued members during the session, namely, Mr. Thomas Wilson, of Leeds, who has been connected with the Society since its foundation; and Sir James P. Kay-Shuttleworth, Bart., who was President for the sessions 1859-60-61.

Dr. MANCHESTER GEOLOGICAL SOCIETY, BALANCE SHEET. Cr.

ABSTRACT OF RECEIPTS.

1876-7.	£	s.	d.
To Bank Interest	0	10	2
,, Birkenhead Dividends	23	14	0
,, Sale of Transactions	3	2	6
,, Subscriptions and Arrears	116	10	0
,, Balance due to Treasurer	11	17	0
	£155	13	8

The Investments consist of £600 Four per cent. Guaranteed Stock of the Birkenhead Railway, in the names of Henry Mere Ormerod and Andrew Knowles.

ABSTRACT OF PAYMENTS.

1876-7.	£	s.	d.
By Balance due to Treasurer	31	17	2
,, Library	14	17	0
,, Reporters	9	9	0
,, Transactions, Reports, &c.	42	18	3
,, Postages, &c.	19	10	0
,, Collector's Commission	5	16	6
,, Rent	30	0	0
,, Insurance	1	5	9
	£155	13	8
October, 1877.			
,, Balance brought down	£11	17	0

HENRY M. ORMEROD, TREASURER.

24th October, 1877.

THE FOLLOWING PAPERS AND COMMUNICATIONS HAVE BEEN BROUGHT BEFORE THE ORDINARY MEETINGS DURING THE SESSION.

1876.

Oct. 31. Annual Meeting.

Nov. 28. "On the Water Supply in the Red Rocks of Lancashire and Cheshire," by Professor Dawkins, F.R.S.

The South Lancashire and Burnley Coal Fields.

A New Description of Brattice Cloth.

Dec. 19. "On the Rocks of the Ballymoney Series, Co. Wexford," by G. H. Kinahan, M.R.I.A.

"On the Drift, Peat, &c., of Heysham, Morecambe Bay," by the Rev. Addison Crofton, M.A.

"On the Method of Working 'Rearing' Mines at Leycett, Staffordshire," with Plans and Sections, by W. J. Grimshaw, F.G.S.

1877.

Jan. 30. "The Condition of Vesuvius in January, 1877," by Professor Dawkins, F.R.S.

Ambulances for Collieries.

"A Description of the Sinking through the Quicksand and other Deposits overlying the Metals at Royton, Lancashire," with Sections, by Mr. Walter Evans.

Feb. 27. "On the Frequent Alteration of Calcareous Fossiliferous Sands to Unfossiliferous Beds, by the Infiltration of Water," by A. W. Waters, F.G.S.

The Ifton Rhyn Coal Beds in Shropshire.

"Irish Drifts," by G. H. Kinahan, M.R.I.A.

Mar. 27. "On the Variation in Thickness of the Coals and Measures of the Lancashire Coal Field," with Diagram, by C. E. De Rance, F.G.S.

"On Underground Fires," with Plan of Workings, by W. J. Grimshaw, F.G.S.

April 24. "On Rolled Pebbles from the Beach at Dunbar," by Dr. W. J. Black.

May 29. The late Sir James P. Kay-Shuttleworth, Bart.

"Oak Trees Found in the Bed of the Irwell at Brooksbottoms," by the Rev. Addison Crofton, M.A.

Discussion on Mr. De Rance's Paper on the Lancashire Coal Fields.

June 23. "Remarks on the Recent Geology of Italy," with Section, by A. W. Waters, F.G.S.

"Old Oak Trees."

"Remarks upon a Flint Arrow Tip and some Flint Flakes found in the Neighbourhood of Bacup; also upon some Stone Implements recently discovered at Land's End, Cornwall, and other places," by John Aitken, F.G.S.

The Report and Balance Sheet were adopted and ordered to be printed.

The following gentlemen were then proposed and seconded, and declared duly elected as Officers and Members of the Council for the ensuing year:—

President:

JOSEPH DICKINSON, F.G.S.

Vice-Presidents:

THOMAS BROOKS,	Hon. A. EGERTON, M.P.
R. D. DARBISHIRE, F.G.S.	G. FEREDAY SMITH, F.G.S.

Ex-Officio Vice-Presidents:

JAMES HEYWOOD, F.R.S.	JOHN AITKEN, F.G.S.
G. W. ORMEROD, F.G.S.	JOHN KNOWLES, M.I.C.E.
E. W. BINNEY, F.R.S.	THOMAS KNOWLES, M.P.
ANDREW KNOWLES.	CLIFFORD SMITH, F.G.S.
G. C. GREENWELL, F.G.S.	W. BOYD DAWKINS, F.R.S.

Treasurer:

HENRY MERE ORMEROD, F.G.S.

Secretaries:

JOHN E. FORBES, F.G.S. | JOSEPH S. MARTIN, F.G.S.

Other Members of the Council:

H. H. BOLTON.	J. H. JOHNSON, F.G.S.
GEORGE GILROY, M.I.C.E.	W. H. JOHNSON, B.Sc.
G. C. GREENWELL, Junr.	PETER PICKUP, F.G.S.
W. J. GRIMSHAW, F.G.S.	J. F. SEDDON.
CHARLES HARDWICK.	A. W. WATERS, F.G.S.
JOHN HIGSON, F.G.S.	GEORGE WILD.

Auditors:

JOHN HEELIS. | CLEGG LIVESEY.

NEW ORDINARY MEMBERS.

Barnes, R. J.
Beswick, James.
Chadwick, W. H.
Derry, Jos.
Edmundson, Thomas.
Goodwin, George.
Grundy, H. T.
Grundy, Joseph.
Handsley, Robert.
Holding, William.
Jobling, John.
Knowles, Lees.
Lord, James.
Moore, Alfred.
Penman, J. H.
Pennington, Rooke, F.G.S.
Place, W. H.
Pickup, T. W.
Tomlinson, Thomas.
Topping, Walter.
Unsworth, John.
Waddington, John.
Waddington, Henry.
West, T. E.
Winstanley, Robert.
Yates, T. M.

NEW HONORARY MEMBERS.

Ernest Vanden Broeck, Brussells.
Charles Brongniart, Paris.
F. V. Hayden, Washington, U.S.A.

DECEASED.

Sir James P. Kay-Shuttleworth, Bart.
Thomas Wilson, Leeds.

RESIGNED.

W. Y. Craig.
Richard Johnson.
Daniel Morris.

LIST OF MEMBERS.

NOVEMBER, 1877.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of election.	
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.

MANCHESTER GEOLOGICAL SOCIETY.

Members are particularly requested to communicate any change of address to the Hon. Secretaries, for which purpose this slip is inserted.

Corrected Address.

Name, ...

Titles, &c., ...

Address, ...

.....

Date, ...

To the
HON. SECRETARIES,
36, George Street,
Manchester.

NEW ORDINARY MEMBERS.

Barnes, R. J.
Beswick, James.
Chadwick, W. H.
Derry, Jos.
Edmundson, Thomas.
Goodwin, George.
Grundy, H. T.
Grundy, Joseph.
Handsley, Robert.
Holding, William.
Moore, Alfred.
Penman, J. H.
Pennington, Rooke, F.G.S.
Place, W. H.
Pickup, T. W.
Tomlinson, Thomas.
Topping, Walter.
Unsworth, John.
Waddington, John.

LIST OF MEMBERS.

NOVEMBER, 1877.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.
1863	Aitken, John, F.G.S., Sandfield, Urmston. *Ex-President.*
1862	Alcock, Thomas, M.D., Oak Field, Ashton-on-Mersey.
1865	Ashworth, Edward, Stagg Hills, Waterfoot, near Manchester.
1864	Ashworth, John, Rose Hill, Turton, near Bolton.
1866	Bamford, J. B., Mining Engineer, Rochdale.
1875	Bangay, Dr. Richard, Cheadle, Cheshire.
1876	Barnes, R. J., Chowbent, near Manchester.
1875	Barrett, W. S., 49, Old Hall Street, Liverpool.
1858	Bazley, Sir Thomas, Bart., M.P., Eyford Park, Stow-on-the-Wold, Gloucestershire.
1877	Beswick, James, Little Hulton, near Bolton.
1862	Beswicke, William, South Parade, Rochdale.
1838	Binney, E. W., F.R.S., F.G.S., 55, Peter Street, Manchester. *Ex-President.*
1867	Bolton, H. H., Newchurch, near Manchester.
1877	*Broeck, Ernest Vanden*, 124, Rue Terre Neuve, Brussells.
1877	*Brongniart, Charles*, Natural History Museum, Paris.
1861	Brooks, Thomas, Crawshaw Hall, Rawtenstall.
1859	Bryham, William, Rose Bridge Colliery, Wigan.
1862	*Buccleuch, His Grace the Duke of, Whitehall Gardens, London, S. W.
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1874	Byrom, W. A., F.G.S., 31, King Street, Wigan.

Year of Election.	
1876	Chadwick, W. H., Bank Collieries, Little Hulton, nr. Bolton.
1859	*Coulthard, J. Ross, F.R.S.L., Croft House, Ashton-under-Lyne.
1874	Crofton, Rev. A., M.A., Reddish Green, Stockport.
1862	Cross, John, 78, Cross Street, Manchester.
1861	Cross, John, Gidlow House, Wigan.
1860	Crowther, Samuel, Bradford Estate Offices, Bolton.
1876	Cunliffe, P. G., The Elms, Handforth, near Manchester.
1860	Darbishire, R. D., B.A., F.G.S., 26, George Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., The Owens College, Manchester. *Ex-President.*
1862	*Derby, The Right Hon. the Earl of, Knowsley.
1877	Derry, Jos, Sneyd Colliery, Burslem.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *President.*
1875	Diggle, A. A., Hindley Green Hall, Leigh.
1859	Diggle, James, West Leigh Collieries, Leigh.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1852	Egerton, The Hon. Algernon, M.P., Worsley Hall, near Manchester.
1838	*Egerton, Sir Philip de Malpas Grey, Bart., M.P., F.R.S., Oulton Park, Tarporley. *Ex-President.*
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1838	*Enniskellen, Earl of*, F.R.S., Florence Court, Fermanagh.
1860	Eskrigge, R. A., F.G.S., 18, Hackin's Hey, Liverpool.
1865	Evans, Walter, Longsight, Oldham.
1863	Farrer, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.

Year of Election.	
1857	Forbes, John Edward, F.G.S., 5, York Street, Manchester. *Hon. Secretary.*
1873	Garforth, W. E., Lord's Field Colliery, Ashton-under-Lyne.
1874	*Geikie, Archibald*, LL.D., F.R.S., Ramsay Lodge, Edinburgh.
1858	Gerard, Lord, of Bryn, Garswood, near Newton-le-Willows.
1856	Gilroy, George, M.I.C.E., Hindley Hall, Wigan.
1877	Goodwin, George, Broomstair Colliery, Denton.
1852	Greg, Robert Philips, F.G.S., Coles Park, Buntingford, Herts.
1863	Greenwell, G. C., F.G.S., 8, Prior Terrace, Tynemouth. *Ex-President.*
1874	Greenwell, G. C., junr., Poynton, near Stockport.
1864	Grimshaw, W. J., F.G.S., Stand, Whitefield, near Manchester.
1877	Grundy, H. T., Radcliffe.
1877	Grundy, Joseph, Radcliffe.
1838	Hadfield George, 24, Fountain Street, Manchester.
1866	Hall, John, Balderstone, Walmersley.
1864	Hall, Robert, Hope Foundry, Bury.
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 72, Talbot Street, Moss Side, Manchester.
1874	*Hawkins, B. W.*, F.G.S., Century Club, East 15th Street, New York.
1875	*Hawkshaw, Sir John*, Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1877	*Hayden, F. V.*, State Geologist, Washington, U.S.A.
1860	Heelis, John, 37, Cross Street, Manchester.
1875	Hetherington, Joseph, 22, Booth street, Manchester.
1874	Hewlett, W. H., Wigan Coal and Iron Co., Wigan.

Year of Election.	
1838	*Heywood, James, F.R.S., F.G.S., 26, Kensington Palace Gardens, London, W. *Ex-President.*
1862	Heywood, Oliver, Acresfield, Pendleton.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1877	Holding, William, Brinsop Hall, Westhoughton, Bolton.
1874	*Hull, Professor Edward*, M.A., F.R.S., 14, Hulme Street, Dublin.
1875	Jackson, J., 5, Wood Street, Bolton.
1877	Jobling, John, Barcroft Hall, Cliviger, Burnley.
1874	Johnson, J. H., F.G.S., 64, Albert Road, Hesketh Park, Southport.
1870	Johnson, W. H., B.Sc., 26, Lever Street, Manchester.
1844	*Joule, J. P., LL.D., F.R.S., 12, Wardle Road, Sale.
1856	Knowles, Andrew, High Bank, Pendlebury. *Ex-President.*
1859	Knowles, John, Westwood, Pendlebury. *Ex-President.*
1864	Knowles, Kay, Swinton Old Hall, Pendlebury.
1877	Knowles, Lees, Westwood, Pendlebury.
1858	Knowles, Thomas, M.P., Ince Old Hall, Wigan. *Ex-President.*
1858	Lancaster John, F.G.S., Bilton Grange, Rugby.
1860	*Litler, H. William, Wallerscote, Leamington.
1862	Livesey, Clegg, Bredbury Colliery, near Stockport.
1838	Livesey, Thomas, Alton Grange, Ashby-de-la-Zouch.
1877	Lord, James, Hill House, Rochdale.
1861	Lynde, J. G., F.G.S., Town Hall, Manchester.
1873	Martin, Joseph S., F.G.S., H. M. Inspector of Mines, Park Villas, Prestwich. *Hon. Secretary.*
1876	Moore, Alfred, C.E., 5, Clarence Street, Manchester.
1838	*Morton, Charles*, The Grange, Southport.
1874	*Morton, G. H.*, F.G.S., 122, London Road, Liverpool.

Year of Election.	
1875	Nesbitt, George, 100, Burlington Street, Manchester.
1864	Nuttall, Thomas, Colliery Surveyor, Bury.
1874	*Ormerod, G. W.*, M. A., F.G.S., Brookbank, Teignmouth.
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester.
1874	*Owen, Professor Richard*, D.C.L., F.R.S., &c., British Museum, London, W.C.
1864	Park, James, Fern Hill, Bury.
1876	Peace, George, Monton Grove, Eccles.
1876	Penman, J. Hugh, 2, Clarence Buildings, Booth Street, Manchester.
1877	Pennington, Rooke, F.G.S., 20, Mawdsley Street, Bolton.
1861	Pickup, Peter, F.G.S., Towneley Colliery, Burnley.
1877	Pickup, Peter Wright, Dunkenhalgh Collieries, Church, near Accrington
1873	Pilkington Alfred, Clifton Collieries, near Manchester.
1873	Pilkington, Edward, Clifton Collieries, near Manchester.
1877	Place, W. H., Hoddleston Collieries, Darwen.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford.
1867	Radcliffe, James, Lord's Field Colliery, Ashton-under-Lyne.
1866	Radcliffe, Richard, Preston New Road, Blackburn.
1874	*Ramsay, Professor A. C.*, LL.D., F.R S., &c., 15, Cromwell Crescent, South Kensington, S.W.
1860	Ridyard, John, Walkden, Bolton.
1873	Seddon, J. F., Great Harwood Collieries, Accrington.
1866	Selby, Atherton, Mining Engineer, Leigh.
1864	Smethurst, William, F.G.S., Garswood Hall Colliery, Ashton, near Wigan.
1873	Smith, Clifford, F.G.S., Parkfield, Swinton, near Manchester. *Ex-President.*
1838	Smith, G. Fereday, M.A., F.G.S., Grovehurst, Tunbridge Wells.

Year of Election.	
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall.
1844	*Sopwith, Thomas*, M.A., F.R.S., F.G.S., 103, Victoria Street, Westminster, S.W.
1862	Spence, Peter, F.C.S., Erlington House, Seymour Grove, Old Trafford.
1859	Statter, Thomas, Stand Hall, Bury.
1876	Thompson, Joseph, F.G.S., Norley Collieries, Wigan.
1877	Tomlinson, Thomas, 3, Richmond Terrace, Whitehall, London, S.W.
1873	Tonge, James, Woodbine House, Westhoughton, near Bolton.
1876	Topping, Walter, Ashton, near Wigan.
1858	*Trafford, Sir Humphrey De, Bart., Trafford Park.
1876	Unsworth, John, Scott Lane Collieries, near Wigan.
1877	Waddington, Henry, Burnley Collieries, Burnley.
1877	Waddington, John, Burnley Collieries, Burnley.
1862	Wadham, Edward, Millwood, Dalton-in-Furness.
1862	*Walsh, Eli, Over Darwen.
1877	Walton, James F., Fern Lea, Rawtenstall.
1874	Waters, A. W., F.G.S., Woodbrook, Alderley Edge.
1877	West, T. E., 65, Werneth Hall Road, Oldham.
1865	Whipp, Thomas, Hawthorn Villas, Prestwich.
1867	Wild, George, Bardsley Colliery, Ashton-under-Lyne.
1859	Wild, John, Glodwick, Oldham.
1860	Wild, Samuel, Dean House, Buersill, Rochdale.
1876	Winstanley, Robert, Lancaster Avenue, Manchester.
1874	*Woodhouse, J. T.*, F.G.S., M.I.C.E., Overseal, near Ashby-de-la-Zouch.
1876	Woodward, H. A., Clifton, near Manchester.
1877	Yates, T. M., Park Hall Colliery, Horwich Junction, near Bolton.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3	Heywood, James, F.R.S., F.G.S.
1843-4-5	Egerton, Sir Philip de Malpas Grey, Bart., M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1849-50-1	Heywood, James, M.P., F.R.S.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1855-6-7	Egerton, Sir Philip de Malpas Grey, Bart., F.G.S.
1857-8-9	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart., M.P.
1861-2-3	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1865-6-7	Binney, E. W., F.R.S., F.G.S.
1867-8-9	Greenwell, G. C., F.G.S.
1869-70-1	Aitken, John, F.G.S.
1871-2-3	Knowles, John, M.I.C.E.
1873-4	Knowles, Thomas, M.P.
1874-5	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, Clifford, F.G.S.
1876-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.

PRESENTATIONS TO THE LIBRARY, 1876-77.

London Geological Society.—Quarterly Journal. Nos. 128 to 131, and Abstracts of Proceedings for the Session 1876-7. From the Society.

London Geologists' Association.—Proceedings. No. 9. Vol. 4. Nos. 1 and 2. Vol. 5. 1876-7. Annual Report, 1876. From the Council.

Manchester Literary and Philosophical Society.—Memoirs. Third Series. Vol. 5. 1876. Proceedings. Vol. 15. 1875-6. Library Catalogue, 1875. From the Council.

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I.—ENGLAND.

London	British Museum.
	Geological Society.
	Geological Survey.
	Geologists' Association.
	Royal Institution.
	Royal Society.
Manchester	The Owens College.
	Literary and Philosophical Society.
	Free Library.
	Scientific Students' Association.
	Salford Royal Museum and Library.
Barnsley	Midland Institute of Mining Engineers.
Birmingham....	Free Library and Museum.
Bristol.....	Naturalists' Society.
Cambridge	Geological Museum, University.
	University Library.
Oxford.....	Bodleian Library.
	Radcliffe Library.

Cornwall	Royal Geological Society, Penzance.
	Royal Institution, Truro.
Truro	Miners' Association of Cornwall and Devon.
Dudley	South Staffordshire and East Worcestershire Institute of Mining Engineers.
Exeter	Albert Memorial Museum.
Leeds	Geological and Polytechnic Society.
	Free Library.
	Philosophical and Literary Society.
Leicester	Literary and Philosophical Society.
Liverpool	Geological Society.
	Free Library and Museum.
Newcastle-on-Tyne	Institute of Mining and Mechanical Engineers.
Sheffield	Free Library and Museum.
South Shields ..	Public Free Library.
Swansea	South Wales Institute of Engineers.
Warwick	Natural History Society.
Watford	Natural History Society.

II.—Scotland.

Edinburgh	Geological Society.
	Royal Society.
	Royal Physical Society.
	Advocates Library.
Glasgow	Geological Society.
	Natural History Society.
Dundee	Free Library and Museum.

III.—Ireland.

Dublin	Royal Dublin Society.
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	Trinity College Library.
Belfast	Natural History Society.

IV.—Foreign Societies.

Berlin	Geological Society of Germany.
Calcutta	Geological Survey of India.

Christiania .... Royal University of Norway.
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VI.—Australia.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XV. VOL. XIV. SESSION 1877–8.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 27th November, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

Mr. W. J. GRIMSHAW, F.G.S., in the Chair;

Mr. C. E. De Rance, F.G.S., of Her Majesty's Geological Survey, was elected an Honorary Member of the Society, and Mr. T. Livesey, jun., of Hatherlow, was elected an Ordinary Member.

Mr. Forbes read a letter from the Registrar of The Owens College, enclosing a copy of the regulations which the Council have made for the admission of students and the public to the Geological Collections. The letter contained the following passages, which fulfil the terms agreed upon at the time when the Collections were handed over to The Owens College, as referred to in the last Annual Report of the Council of this Society:—

> **The Geological Collections are now open to the Public on Tuesdays, Thursdays, and Saturdays, from 10 a.m. to 4 p.m., and on Saturday evenings from 6·30 to 9 p.m.**
>
> **They are further open to Students on Wednesdays and Fridays from 10 a.m. to 4 p.m.; and on Friday evenings from 6.30 to 9 p.m.**
>
> **The Museum is closed during the month of August, and from the 23rd December to the 2nd January inclusive.**
>
> **Admission free, and without ticket.**

QUARTZYTE (QUARTZ-SCHIST), QUARTZ-ROCK (GREISSEN).

By G. Henry Kinahan, M.R.I.A., &c.

Quartz-schist, *Quartzyte*, *Quartz-rock*, and *Greissen* are names that many geologists suppose indicate only one kind of silicious rock; they considering that the rocks so called are metamorphosed sandstones and grits. Some of my predecessors on the Irish branch of the Government survey, however, appear to have come to a different conclusion.* Mr. A. Wyley, while mapping the rocks of South-East Ireland, appeared to be of the opinion that quartz-rock was different to quartzyte, although his reasons for this supposition do not seem to have been published. Subsequently the late Mr. John Kelly read a very able paper on the subject before the Geological Society, Dublin (Jour. Geol. Soc., Dublin, vol. v., p. 237), in which he distinctly shows that there are intrusive and bedded "quartz-rocks;" while the late Professor Jukes seemed to believe that different kinds of rocks were classed together under these names, but he does not attempt to separate them.

From the rocks that have come under my notice during the examination of Ireland, I believe that *Quartzyte* or *Quartz-schist* is a distinct silicious rock, from *Quartz-rock* or *Greissen*.

Quartzyte or Quartz-Schist is a metamorphic rock, more or less foliated, and allied to the other varieties of schist, into many of which it graduates, by a loss of its quartz. It originally was an arenaceous sandstone, or some other silicious mass, that has acquired its present nature and structure from metamorphic action. Essentially it is a

* I hear that this subject has been written on by some of the American geologists, but unfortunately I cannot learn where their opinions have been published.

quartzose rock; but varieties are more or less micacious, felsitic, chloritic, or talcose; some one or other mineral predominate, changing the rock from its normal character. In quartzyte there is always foliation, due to the subsequent changes that have taken place in the rocks during metamorphism, and this structure appears to have always followed a conspicuous structure (generally foliation or cleavage) in the original rocks.

QUARTZ-ROCK or GREISSEN is a crystalline granular aggregate of quartz, usually containing a little mica, or felsite, or some other mineral. Sometimes it presents the appearance of a normal intrusive rock (Fig. 1), but often it appears as if it had been deposited in cake-like masses from solution (Fig. 2). *Vein-quartz* is deposited from solution, and in aspect some masses of quartz-rock are very similar; both these kinds of rocks having a structure, which in the vein-quartz is supposed to be due to its having been deposited from solution. Some of the felsitic varieties of quartz-rock are so felsitic that they are undistinguishable from *petrosilex* (Felsite of Cotta), while in other places it is associated with granite, and under such conditions it merges into the granite. In the intrusive masses of quartz-rock there is often a bed-like structure, similar to that not uncommon in many intrusive granites, and probably due to the mass cooling in layers.

The silicious rocks of Ireland, that are usually classed indiscriminately together, may be separated into the following groups:—

Group A. *Quartzyte*, or metamorphosed silicious rocks.

Group B. *Quartz-rock*, or silicious rocks intruded into their present position.

Group C. *Quartz-reefs or veins*, or silicious rocks deposited in fissures from solution.

QUARTZYTES occur among the metamorphic rocks of Cambrian, Cambro-silurian (Lower Silurian), and Silurian

(Upper Silurian) ages, in South-East Ireland (Dublin, Wicklow, and Wexford), in West Ireland (Galway and Mayo), and North Ireland (Sligo, Londonderry, Tyrone, and Donegal), &c. Usually they originally were either sandstones or grits; but in some localities quartz-rocks, by metamorphic action, have been changed into quartzyte. In all metamorphic countries the quartzite (metamorphosed grits and sandstone) occurs as regularly stratified rocks. In such cases there are rarely well-defined boundaries between the quartzyte and the associated schists; as one usually graduates into the other, both horizontally and vertically. This is due to the eminently silicious rocks only changing into typical quartzyte; while impure sandstones, slates, and shales become micalyte (*mica-schist*), hornblendyte (*hornblende-schist*), felsilyte (*felsite-schist*), or some other variety of schist, some sub-varieties being quartzitic, and thus each merging into quartzyte.

In West Ireland there are large tracts of quartzytes (principally metamorphosed Cambrian rocks). In the same district there are also peculiar tracts of quartzyte in the Silurians of the Mweelrea mountains, County Mayo, where some of the sandstones of the Mweelrea series contain isolated patches of quartzyte. These patches may extend into two or more beds, but are bounded by joint lines. The altered portion seems to have been metamorphosed by aqueo-igneous actions invading a space bounded by lines of joints. These patches of quartzyte may have three or more sides, formed by joint lines, the rocks outside the boundary sometimes being a little changed, but in general they seem to be unaltered.

In all countries in which metamorphic action has taken place, not only the sedimentary rocks but also the associated eruptive rocks were affected; and in such areas in which quartz-rocks occurred among sedimentary rocks, the former have been changed by metamorphic action into quartzyte.

This is very conspicuous in the Forth Mountain, County Wexford, and neighbouring country, where the cakes of quartz-rock in the Cambrian rocks have a more or less well-developed foliation, and must now be called quartzyte. These Cambrian rocks belong to the "Sub-metamorphic" rocks of the Indian geologists; and it seems remarkable that while the quartz-rocks are well altered by the metamorphism, also the slates and shales, that the same action has had very little effect on the associated grits.

Quartz-reefs or veins, may also occur in the areas that subsequently were metamorphosed, and necessarily they were altered with the other rocks. These altered vein rocks are most interesting, especially when containing mineral. This subject, however, is foreign to the present communication, and we will confine ourselves to the quartz-reefs. The quartz-reefs when altered may have a regular foliation development, but more general the foliation is tangled; usually the metamorphic action seems to have separated the argillaceous and silicious portions of the reef, so that a rib or ribs of schist occur in the reef. In the case of one of the quartz-reefs on the south coast of Wexford (Fig. 8) green and purple shades occur in the quartz.

Quartz-rocks.—In the county of Galway quartz-rocks occur making, in mass, like intrusive granite, and graduating into the latter rock; so that it is perfectly impossible to draw a boundary between the different rocks. In the same county are masses and dykes of metamorphose rocks, portions of which would have to be called quartzyte while others are a felsitic foliated rock. These rocks seem to be dykes and protrusions of a rock that in part was felsitic, but in others portions highly silicious; while subsequently all were altered along with the associated sedimentary rocks.

In the Cambrian and Cambro-silurian rocks of south-east Ireland the relation between the quartz-rocks and associated rocks are more distinct. In the promonotory of Howth,

County Dublin, the Cambrian rocks to the northward are so little altered that the late I. R. Kinahan, M.D., found in them, at Puck Rock, Oldhamia Antiqua; but to the south of the promontory they are sub-metamorphic. To the quartz-rocks that come up as protrusions in the Cambrian, Mr. A. Wyley directed especial attention, and pointed out that to the north they are unaltered, while to the south, when a foliation has been developed in them, they are quite distinct from the quartzytes or metamorphosed grits. A further distinction not mentioned by this observer is, that while the quartz-rock both altered and unaltered is an eminently water-bearing rock, the quartzytes are not.

In the unaltered Cambrian rocks of Bray Head, County Wicklow, are great protrusions and dykes of quartz-rock. Fig. 7 is a sketch section of one of these dykes in the Cambrian rocks at the small headland about a quarter of a mile south of Bray Head. The rocks to the north of this dyke are ochreous, and have been altered, but not sufficiently to obliterate the Oldhamia that occurs in them; while the rocks to the south of the dyke seem to be unaltered. In this dyke there is a nearly horizontal structure. The alteration alongside the dyke possibly may not be due to it; for if subsequent to its intrusion a fissure had opened alongside it, in which hot vapour came up, the latter may have caused the alteration in the Cambrian rocks.

In the Carrick mountains, north-west of Wicklow town, there are great cakes of quartz-rock in the unaltered Cambrian rocks, while farther westward there are metamorphosed quartz-rocks associated with schists and gneiss. These schists and gneiss are of a questionable age, but as a discussion on this subject would be outside our subject we will go on to the next locality.

In the County of Wexford there are quartz-rocks and quartzyte, in both the Cambrian and the Cambro-silurian rocks. On the East Coast of Wexford, at Askingarron

(Fig. 6), three miles north of Cahore, are remarkable protrusions of quartz-rock, coming up through the unaltered Cambrian, Oldhamia Antiqua having been found in a bed alongside. In the dykes of quartz-rock there is a regular nearly horizontal structure.

We have previously mentioned the altered quartz-rocks in the Cambrian of the Forth Mountain and neighbouring country, but here attention may be directed to the quartzytes near Greenore (altered grits), in the same group of rocks, as they are typical quartzytes, and very unlike the undurated grits found associated with the altered quartz-rocks in the Forth Mountains.

A place to which special attention should be directed is the South-West Coast of Wexford (Bannow and Haggard), as here—in altered Cambrians and unaltered Cambrians and Cambro-silurians—are various silicious rocks, allied to those now being described; namely, quartzytes (altered quartz-rocks), quartz-rocks, felsitic-quartz-rocks (petro-silex ?), and quartz-reefs. In the townland of Ballymadden is a mass of quartz-rock intruding into the associated schist. (Fig. 5.) To the westward the micalyte seems to lie on the mass, and possibly the quartz-rock may not have been originally intruded, but rather a protruded mass, that was enveloped by the accumulation of the strata that are now changed into micalyte; but as no foliation can be seen in it, while in all the other masses of quartz-rock in these altered Cambrian rocks foliation is developed, possibly it was protruded after the metamorphic action—and may be of the same age as the masses and dykes of quartz-rock in the Cambro-silurians.

Further westward there are intrusions in both the unaltered Cambrians and Cambro-silurians, some being typical quartz-rock, others felsitic-quartz-rock (petro-silex ?), while in places are rocks that seem to be a gradation between these. In Figs. 1 and 8 some of these petro-silex(?) protrusions are represented. In Fig. 1 the petro-silex appears to be

intimately connected with the quartz-rock. Here the masses of both kinds of rocks seem to be intrusions, while the mass of quartz-rock represented in Fig. 2 might have been the depositions from a silicious spring, that were accumulating while strata were being deposited around it.

In Fig. 4 are given sketch plan and section, of masses of quartz-rock at the small promontory of the Bride's Chamber. The mass of quartz-rock to the top of the plan, and to the left hand of the section, appears to be intrusive, while the other mass lies on green shales, and has in it a structure parallel to the bedding of the shale.

From the facts that have been given, it seems probable that quartzytes are metamorphosed silicious rocks, let them originally be sandstones, grits, or quartz-rock—but what is the origin of quartz-rock?

QUARTZ-ROCK OR GREISSEN may be divided into two groups. 1*st*, those associated with intrusive granite, and, 2*nd*, those occurring as independent bosses, intrusions, and dykes.

Group 1. Greissen that graduates into granite has already been treated of in a communication laid before the Royal Irish Academy, in which suggestions as to its origin were given.*

There it was suggested that as molten granite probably cooled in zones, successive quantities during cooling separated from the molten mass, each successive separation being more silicious than that which preceded it. Such separation, if continued long enough, would eventuate in the residue of the original molten mass being nearly pure silex. Therefore forming one protrusion, there may be rocks that graduate from normal granite into rocks so silicious that they may be classed as quartz-rock or greissen. This probably was the origin of the greissen associated with intrusive granite, but

* "Granite and other ingenite rocks of Yarconnaught and the Lower Owles." Proc. Royal Irish Academy, ser. ii., vol. 2.

it would scarcely explain the origin of the quartz-rocks in the second group.

Group 2. Some of these quartz-rocks seem to be erupted, while others would appear as if they were deposited from solution. If this is correct, there are two kinds of rocks having different origins but similar appearances.* Against the supposition of their being eruptive, it should be mentioned that small pieces occur, very similar in shape and appearance to the larger masses, while from the smallest piece to the largest mass there seem to be a regular gradation as to size. This, however, may be explained.

If these silicious rocks are due to incipient vulcanicity, which found vent at the sea bottom, or on tidal shores, in springs of water more or less charged with silica, when the silica was in excess, incrustations of quartz would accumulate round the orifice of the springs; while in other cases, owing perhaps to currents or the small quantity of silica in the water, this substance would be deposited about certain centres only (vegetable or other organic matter) to which it was attracted. In some places the springs would be isolated, and silica form detached masses (Figs. 1, 2, and 4), but in other places a series of springs would be in operation along a line or lines of fracture or fissures, thus forming long, although irregular, accumulations (Geol. Map of Ireland, sheet 130). These masses would protrude into the associated rocks, although lying in the same strikes; and although the latter were being deposited while they were accumulating.

Newer rocks which seem to have an alliance with the quartz-rock, and possibly may help to explain their origin, occur in various places in Ireland. Margining the carboniferous limestones of the plains of Limerick are "Old red

* Among the varieties of granite are the "endogenous veins" of Sterry Hunt, and the veins of granityte; the first being deposited from solution, while the second are eruptive veins, although the aspect of both are very similar.

sandstones" *(Lower Carboniferous grits)*, and in many places the basal bed of the latter is a quartz-rock that sometimes is replaced by a silicious limestone; but both this quartz-rock and the limestone appear to have been deposited from solution, as if they marked the dawn of the vulcanicity that subsequently was more intense, as shown by the great sheets of doleryte euryte and tuffs found interstratified with the Carboniferous rocks of Limerick. It is an established fact that in many regions where volcanic action is now in operation, and also in others where the forces are apparently dormant, vulcanicity shows its presence, although it may be faintly, in silicious, calcareous, and such like springs. If dying out vulcanicity thus acts, somewhat similar phenomena may mark its advent.

That an excessive discharge of silica was an adjunct of vulcanicity in the early stages of the earth's history seems also suggested by the following:—In the Carboniferous limestone of the County Limerick, on the same horizon as the igneous rocks, are zones of considerable thickness, made up almost entirely of beds of chert. Most of the bedded igneous rocks of this county are on two geological horizons, both of which are marked by these "cherty zones," and their zones extend not only over the whole of the County Limerick, but also occur in the whole of Munster and in part of the central plain of Ireland, while the isolated Igneous centres as that of Croaghan Hill, County Meath, are on one of these horizons. Moreover, in the plain of Limerick, between the regular cherty horizon, local chert zones occur wherever there are small Igneous centres.

If these chesty zones are the result of vulcanicity, may not all the chert in the Carboniferous limestone be due to vulcanicity? And the question may even be extended to the flints in the chalk and the menilytes of the Tertiary limestones. The latter, however, are questions more fitting to the English and Continental geologists than to me, and

perhaps may be worked out by some of the members of the Society. In Ireland, however, there seems to be marked relations between the carboniferous chert and vulcanicity.

It has been suggested that the dawn of the vulcanicity in the Carboniferous rocks of Limerick was marked by a deposit of quartz-rock,* and a very similar deposit seems to have marked the dawn of vulcanicity in the Silurian period. In the County Mayo, at the base of the Mweelrea series (Upper Llandovery ?), there is usually a massive bed of euryte, while in those places that it is absent, its place is taken by a massive quartz-rock. There are also, in connection with the eurytes, masses of limestones, somewhat like those associated with the carboniferous basal quartz-rock.

In the metamorphic Cambrian or Cambro-silurian of West Galway (to which formation they belong is undecided) are great interbedded masses of igneous rocks, and in the underlying Cambrion rocks are masses of quartz-rock and felsitic-quartz-rock. In the Cambro-silurian of Wexford, in the "Dark shale series," (Llandeilo ?) are masses and dykes of quartz-rock, while higher up, in the "Ballymoney series," are great sheets of interbedded igneous rocks. In the lower beds of the Cambrian of Wicklow and Wexford are the previously mentioned quartz-rocks, and in the highest beds, such as those near Greenore and Carnsore, at the south-east of the County Wexford, are inter-stratified Igneous rocks; thus proving that in the Carboniferous, Silurian, Cambro-silurian, and Cambrian rocks of Ireland, there are quartz-rocks below, in the lower beds; while above, in the higher beds. are inter-stratified Igneous rocks.

The conclusions arrived at and laid before the Society in this paper are:—

First.—All the rocks at present classed as *Quartzytes* are not of similar origin.

* It should be mentioned that the rocks called the "Old red sandstone" in Munster are evidently the basal (arenaceous) Carboniferous rocks.

Second.—Some of these rocks are normal *quartzyte*, that is, rocks due to the metamorphisis of grit sandstone and other silicious rocks; while others (*quartz-rock*) are not, but have been intruded into their present positions.

Third.—Some *Quartz-rocks* may have been deposited as irregular cakes round springs, thus forming masses afterwards to be enveloped by the deposition of strata around them; while others are normal eruptive rocks.

Fourth.—*Quartz-rocks* are either normal eruptive rocks or cakes formed by depositions from mineral springs, and both classes should be grouped with the igneous rocks, as both kinds are more or less directly the products of vulcanicity.

EXPLANATION OF PLATE.

Fig. 1. Sketch plan of masses of Quartz-rock and Felsitic-quartz-rock in Cambrian rocks, east of Cross Lake, townland of Haggard.—South West coast of Wexford.

Fig. 2. Sketch plan of a mass of Quartz-rock in grey and greenish shales.—south of Cross Lake.

Fig. 3. Sketch plan of a small tract of Quartzyte in Mwellrea sandstone (Silurian).—Mwellrea, County Mayo.

Fig. 4. Sketch plan and section of the Bride's Chamber Promontory, Haggard, South-west Coast of Wexford, showing two masses of Quartz rock in Cambrian shales.

Fig. 5. Sketch plan of part of a mass of Quartz-rock protruding into micalyte and argillyte (altered Cambrians).

Fig. 6. Sketch section of two dyke-like protrusions of Quartz-rock in Cambrian rocks, townland of Askingarron, East Coast of Wexford.—* Oldhamia.

Fig. 7. Dyke of Quartz-rock in Cambrians, near the Brandy Hole, Bray Head, County Wicklow.—* Oldhamia.

Fig. 8. Sketch plan of a Quartz-reef and a Felsitic-quartz-rock, coming up through Cambro-silurian rocks. A, Quartzose breccia (fault-rock) B, and D, Purple and green shaly stuff. C and E, Quartz-ribs.—South Shore of Bannon, County Wexford.

Plate for G.H. Kinahan's paper on Quartzyte and Quartz Rock.

Fig 1.

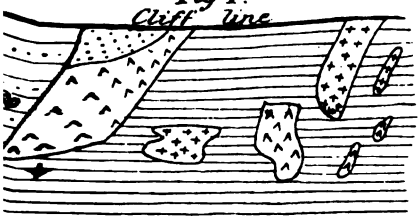
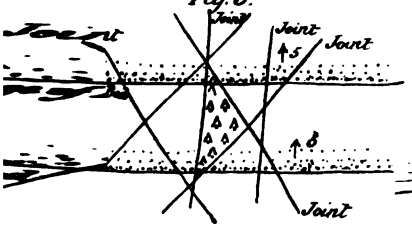


Fig. 2

Fig. 3.



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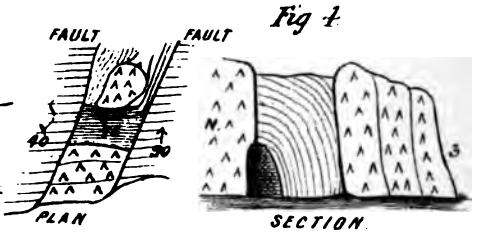


Fig 5

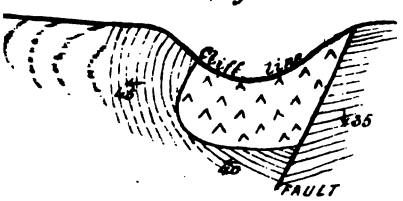


Fig 7

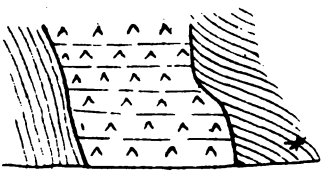


Fig 6

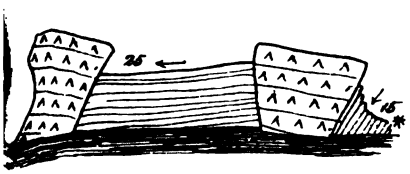
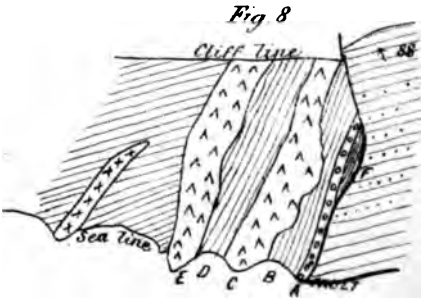
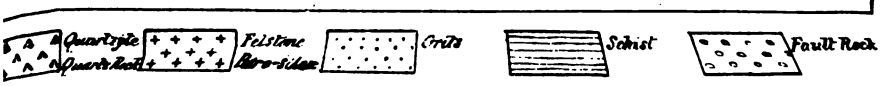
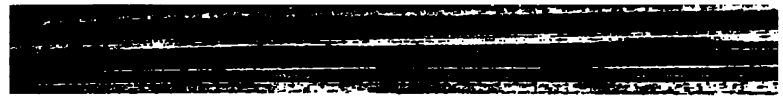


Fig 8







TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVI. VOL. XIV. SESSION 1877–8.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 19th December, 1877, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

The President, JOSEPH DICKINSON, Esq., F.G.S., in the Chair.

ON THE DAVY LAMP AND BLASTING IN MINES.

BY JOSEPH DICKINSON, F.G.S.

The Davy lamp is known to be safe only under certain circumstances. It may be put into an explosive or inflammable mixture, and if withdrawn quietly the gas flashes or burns inside the gauze, sometimes putting the light out and sometimes not, but without flame passing through the gauze. The standard mesh of the gauze is 784 apertures (28 × 28) to the square inch. With this the cooling property appears to be such as to prevent the ignition of gas externally until the gauze becomes red hot, or unless there be some defect in the lamp, or some easily firing or flaming substance on the gauze. I have, on hundreds of occasions, had to trust my life to this kind of lamp. The practice is to lift it up towards the roof. If held for a short time, till it gets

heated, it apparently indicates better. Many prefer trying with a very small light, as the indication may then be seen best. Looking through blue glass is also now said to be an improvement. The usual indication is a blue cap on the flame, but the whiter it is, the quicker it fires. If the cap begins to tail up, or the flame to flutter, and there be time, it is best to lower the lamp, without allowing it to fire, but always gently. When the top of the lamp touches the roof without showing gas, the practice in some districts—but which is reprobated in others—is to place the lamp sideways, in order to test the uppermost part, where firedamp naturally lies.

The gauze of the Davy, as commonly used, is about 5½ inches in length by 1¼ inches in diameter, with a cap for the top. This, according to the experiments recorded (page 39, Vol. 17, North of England Institute of Mining Engineers), admits of flame passing through, or of external ignition, at a velocity of 11½ feet per second, or 690 feet per minute.

Should a person get into an explosive mixture, where the lamp fills with flame and continues burning, notwithstanding that the wick be drawn down, and there is no escape, the Special Colliery Rules of this district enjoin that he must smother it out. How that may best be done is left to his own discretion. If water were near he might probably dip it in, or if dust cover it, or put it in his woollen jacket. Under such circumstances there is some risk.

The latest fatal instance of gas firing through the gauze of a Davy lamp, that I remember investigating, occurred on Sunday, the 30th of March, 1873, as two miners were repairing an airway in the Old Mine, at Bardsley Colliery, Ashton-under-Lyne. Without any previous warning, it appears, a current of inflammable gas suddenly came upon them, and soon fired through one of the lamps. Both miners were badly burned, but one survived. He described

that on finding the gas firing in the lamps they pulled down the wicks with the pricker, but that being of no avail, consequent upon the gas burning in the lamps, and the lamps getting too hot to handle, the flame passed through the gauze. The best "science man" in the world, he said, could have done no more than they did under the circumstances. The outburst of gas, it was afterwards found, came from a rent in the floor at a face of work. The issue, when I visited the place on the third day afterwards, was still continuing, but apparently pining off.

Self-extinguishing safety lamps, such as the Stephenson, may generally be relied upon in such emergencies, but they are not without drawbacks, which greatly restrict their general use.

In Scotland, the Davy lamp is used by the firemen in trying places, but that used by the miners is called the gauze lamp. The principle of the two lamps is the same, the difference being that the gauze lamp is larger, and gives better light. The gauze lamps are of two sizes, both much larger than the Davy. The larger one has a gauze cylinder $6\frac{1}{2}$ inches in height by $3\frac{1}{2}$ inches in diameter, surmounted by a conical top 3 inches high, the gauze at the upper part of the cone being double. The smaller one has the gauze cylinder $4\frac{1}{4}$ inches high by $2\frac{3}{4}$ inches in diameter, with the cone $2\frac{1}{2}$ inches high, and double at the top. Each lamp has a padlock and key. The smaller lamp shown has a mesh of nearly 784 apertures to the square inch, but the larger one is more open. These lamps have apparently been long used for partial working in Scotland, and are said to have stood many tests without flame passing through the gauze. It seems, however, that in a few instances they are giving place to the Davy. The Davy, having only a $1\frac{1}{2}$ inch cylinder, is presumably safer, but it gives a poor light; and in Scotland it seems the practice, when the fireman is going

his rounds with it, he carries the lamp of the country also for light.

At a time like this, when the public mind has been excited by a very serious explosion, and when, as I am informed, the Coal Association are discussing the question of lighting and blasting in mines, it may be useful to review the regulations which are now in force.

The rules under the Coal Mines Act are very strict, and the special rules of this district supply further conditions. They are as follows :—

GENERAL RULES.

2. *Inspecting and reporting on Gaseous Mines.*—In every mine in which inflammable gas has been found within the preceding twelve months, then once in every twenty-four hours if one shift of workmen is employed, and once in every twelve hours if two shifts are employed during any twenty-four hours, a competent person or competent persons, who shall be appointed for the purpose, shall, before the time for commencing work in any part of the mine, inspect with a safety lamp that part of the mine, and the roadways leading thereto, and shall make a true report of the condition thereof, so far as ventilation is concerned, and a workman shall not go to work in such part until the same and the roadways leading thereto are stated to be safe. Every such report shall be recorded without delay in a book which shall be kept at the mine for the purpose, and shall be signed by the person making the same.

6. *Withdrawal of Workmen in Case of Danger, and inspecting and reporting on cause.*—If at any time it is found by the person for the time being in charge of the mine, or any part thereof, that by reason of noxious gases prevailing in such mine or such part thereof, or of any cause whatever, the mine or the said part is dangerous, every workman shall be withdrawn from the mine or such part thereof as is so found dangerous; and a competent person, who shall be appointed for the purpose, shall inspect the mine or such part thereof as is so found dangerous, and if the

danger arises from inflammable gas shall inspect the same with a locked safety lamp, and in every case shall make a true report of the condition of such mine or part thereof; and a workman shall not, except in so far as is necessary for inquiring into the cause of danger, or for the removal thereof, or for exploration, be re-admitted into the mine, or such part thereof as was so found dangerous, until the same is stated by such report not to be dangerous. Every such report shall be recorded in a book which shall be kept at the mine for the purpose, and shall be signed by the person making the same.

7. *Safety Lamps and Lights.*—In every working approaching any place where there is likely to be an accumulation of explosive gas, no lamp or light other than a locked safety lamp shall be allowed or used; and whenever safety lamps are required by the Act, or by the special rules made in pursuance of the Act, to be used, a competent person, who shall be appointed for the purpose, shall examine every safety lamp immediately before it is taken into the workings for use, and ascertain it to be secure and securely locked; and in any part of a mine in which safety lamps are so required to be used, they shall not be used until they have been so examined and found secure and securely locked, and shall not without due authority be unlocked; and in the said part of a mine a person shall not, unless he is appointed for the purpose, have in his possession any key or contrivance for opening the lock of any such safety lamp, or any lucifer match or apparatus of any kind for striking a light.

8. *Gunpowder and blasting.*—Gunpowder or other explosive or inflammable substance shall only be used in the mine underground as follows:—

(*a.*) It shall not be stored in the mine:

(*b.*) It shall not be taken into the mine, except in a case or canister containing not more than four pounds:

(*c.*) A workman shall not have in use at one time, in any one place, more than one of such cases or canisters:

(*d.*) In charging holes for blasting, an iron or steel pricker shall not be used, and a person shall not have in his possession

in the mine underground any iron or steel pricker; and an iron or steel tamping rod or stemmer shall not be used for ramming either the wadding or the first part of the tamping or stemming of the powder:

(*e.*) A charge of powder which has missed fire shall not be unrammed:

(*f.*) It shall not be taken into or be in the possession of any person in any mine, except in cartridges, and shall not be used, except in accordance with the following regulations, during three months after any inflammable gas has been found in any such mine; namely,

(1.) A competent person, who shall be appointed for the purpose, shall, immediately before firing the shot, examine the place where it is to be used, and the places contiguous thereto, and shall not allow the shot to be fired unless he finds it safe to do so; and a shot shall not be fired except by or under the direction of a competent person, who shall be appointed for the purpose:

(2.) If the said inflammable gas issued so freely that it showed a blue cap on the flame of the safety lamp, it shall only be used—

(*a.*) Either in those cases of stone drifts, stone work, and sinking of shafts, in which the ventilation is so managed that the return air from the place where the powder is used passes into the main return air course, without passing any place in actual course of working; or

(*b.*) When the persons ordinarily employed in the mine are out of the mine, or out of the part of the mine where it is used:

(*g.*) Where a mine is divided into separate panels, in such manner that each panel has an independent intake and return air way from the main air course and the main return air course, the provisions of this rule with respect to gunpowder or other explosive inflammable substance shall apply to each such panel in like manner as if it were a separate mine.

SPECIAL RULES.

32. *Safety Lamps and Lights.*—In addition to the observance of General Rule 7, whenever safety lamps only are required to be used, he shall have no light there except in a good safety lamp; and he shall not attempt to use the lamp until it has been first examined and locked by a person duly authorised; and he shall not unlock or open the lamp. If the lamp become damaged, he shall at once extinguish it. He shall take or send each lamp extinguished in consequence of damage, or by accident, to the appointed station, where the proper officer will either unlock and re-light it, or provide him with a fresh lamp. If the gauze becomes smeared with oil, or clogged with dust, he shall cease using the lamp until it shall have been properly cleaned; and no oversight on the part of the person authorised as above shall be an excuse for any work person having in the mine an open, unlocked, insecure, or defective safety lamp.

33. Where naked lights are prohibited, he shall not smoke or have there any tobacco pipe, or tobacco for smoking; and if there is reason for suspicion, he shall be subject to be personally searched for tobacco pipes, tobacco for smoking, matches, and keys, or any other contrivance for opening a safety lamp, by the underlooker or fireman.

34. Should any work person get into fire-damp, he shall not throw away his lamp, nor attempt to blow it out, but shall draw down the wick, hold the lamp near the floor, avoid jerking it, and take it steadily into the fresh air. If the gas fire in the lamp where he cannot take it into fresh air, he shall smother out the light or extinguish it in water.

35. Where naked lights are used, and he is provided with a safety lamp, he shall at the beginning of a shift, and also after any intermission of working, try his place with the lamp, and not with a naked light, to see if there be fire-damp.

36. He shall not, without the express consent of his superior officer, leave any light in his working place, nor in any part of the workings, unless it be left under the care of some person remaining therein.

37. *Gunpowder.*—In addition to the observance of General Rule 8, where naked lights are used and he is provided with a safety lamp, he shall on returning. after a shot has been fired, try his place with the safety lamp, to see if there be fire-damp. If a shot misses fire, he shall not, except in case of emergency or when specially allowed to do so, return to it until after the lapse of one hour.

61. *Lampmen.*—The person or persons appointed to examine and lock the safety lamps shall daily examine and lock each lamp, and see that it is in good order and clean, and free from any broken wire or wide space in the gauze; and also that it has a closely-fitting hoop inside the gauze, and that the pricker fits the hole.

The powder rule is very stringent. Powder may only be taken into a mine in canisters, containing not more than four pounds. If firedamp has been found in that part of the mine within the preceding three months, the powder must be in cartridges, and the shots may only be fired under the supervision of a competent person, appointed for the purpose. If the mine be very fiery, according to the test enjoined of showing indications of gas as it issues from the strata, notwithstanding adequate ventilation, shots may only be fired when the ordinary work persons are out of that panel of the mine. And, lastly, it may not be used at all, unless it is safe. Further than this it appears impossible to go, unless by total prohibition. The condition of the use of open lights—as shown by the explosions at Blantyre, with 209 lives lost, and 114 at Cymmer—is unreliable. But to forbid the use altogether would be to sacrifice the advantages given by science.

Mr. W. J. Grimshaw said that he was sure that none of those present were acquainted with the kind of lamps which Mr. Dickinson had exhibited. The gauze certainly did not seem to contain 784 orifices to the square inch, it was more like 24 or 26 gauze, and was very much coarser

than the ordinary wire gauze. The Scotch Gauze lamps, which Mr. Dickinson showed, seemed very much lighter than the ordinary Davy lamp used in this district, even taking into account the extraordinary difference in size.

Mr. HALL asked Mr. Dickinson if any provision was made in the larger of the two lamps exhibited for thickening the wires, &c., as to meet the larger diameter of the gauze.

The PRESIDENT: The gauze of the large lamp speaks for itself. It seemed to me to be about only the ordinary size of wire used in our Davy lamps, but it has not got so many wires to the square inch. The openings are larger—24 to an inch instead of 28. In some mines these lamps are now giving place to the Davy, though they are still the common working lamps throughout Scotland. One of the advantages of the Scotch lamp is that it gives a better light. But for testing they always carry a Davy lamp. Whether these Scotch lamps are as safe as the English has not yet been tested; presumably they are not so safe, judging by the size of them. In the experiments I have alluded to, recorded in the Transactions of the North of England Institute of Mining Engineers, they first commenced to make experiments in a box. They placed the Davy lamp in a box, filled with an explosive mixture, and whirled the lamp round, noting the velocity at which the gas fired. The drawback to that experiment was that they were whirling the lamp round in the same atmosphere in which it was, during the time, consuming that explosive mixture and leaving some of the products of combustion in which it had to work. They afterwards got a long tube and passed the different mixtures, and at different velocities, through it, and they had the lamps stationed in front of a glass window, so that they could see it during the operation; they had also one of my anemometers placed opposite another glass window so that they could observe the actual velocity at which the current

was travelling, and until the lamp got red hot and the gas fired.

Mr. HALL said that the President, at the close of his paper, with regard to the use of gunpowder in mines, remarked that if gas was found issuing freely from the strata, notwithstanding perfect ventilation, a shot was not to be fired until all the men had been withdrawn from that panel of the mine.

The PRESIDENT: That is the Act of Parliament.

Mr. HALL: I would like Mr. Dickinson further to explain what is meant by gas issuing from the strata. We may find in a place properly ventilated little blowers that will fire in the lamp, that being so, I would ask whether that would be a fair condition under which a manager would be bound to withdraw his men before firing a shot.

The PRESIDENT: It is not for me to say whether it is a proper or improper condition. I say it is the mining law. It is required by the Act for the Regulation of Mines.

Mr. HALL: I will take it either way—whether it is your opinion, or whether it it is the law.

The PRESIDENT: It is the law, if notwithstanding adequate ventilation, the issue of gas from the strata is such as even to show in the lamp—not actually fire, but if there is a mere indication that it is going to fire—no shot shall be fired unless the men be withdrawn from that panel of the mine. The Act is very strict.

Mr. GEORGE WILD pointed out that, according to his experience, those lamps with the larger diameter of gauze were the safer. A jet of common gas would ignite at the flame inside a Davy lamp in about 30 seconds, whereas, if the glass be taken out of Stephenson lamp it was almost impossible to ignite it. He also found that gas would not explode through copper gauze, where it would explode through the ordinary iron gauze of a Davy lamp of the same size.

ON THE RESOURCES AND FUTURE DEVELOPMENT OF THE COAL FIELDS OF EUROPE.

By W. H. Johnson, B.Sc.

The extent and development of our coal fields must always be a subject of the greatest interest to Englishmen, as our country owes much of its manufacturing supremacy to the abundance and cheapness of the supply of fuel. Should this supply be materially diminished or should other countries, by rapid development of their mineral wealth, outstrip us in the cheapness of their fuel, our manufacturing supremacy will be endangered. Hence, it is important for us to be acquainted with the extent and situation of the coal fields of other countries and to watch carefully the development of mining enterprise all over the world.

Europe, compared with America and Asia, is but scantily supplied with fuel; in Asia, India alone has a greater area of coal fields than all Europe, while China has still greater stores of fuel. Upwards of 200,000 square miles, or one-tenth of the whole area of the United States of America consists of coal measures, while in Great Britain the area of the coal fields is only $\frac{1}{28}$ of the whole or some 7,000 square miles, and yet it probably exceeds that of all the other countries of Europe put together, Russia alone excepted.

The present production of coal in the world is approximately, as follows:—

Great Britain, 1876 ..	133,344,766	tons.	Mineral Statistics.
United States, 1874 ..	44,091,922	,,	
Prussia, 1876	42,819,345	,,	Zeitschrift für Berg Hütten, &c.
Belgium, 1876	14,786,160	,,	
France, 1867	12,148,223	,,	
Austria, 1862.....	4,552,500	,,	

Australia and New Zealand.....	3,000,000	„	Estimated.
British North America	1,500,000	„	„
Mexico	1,000,000	„	„
Chili	1,000,000	„	„
Italy, 1862.....	775,000	„	
British Indies, 1868 ..	564,933	„	
Spain, 1862	388,950	„	
Russia and Poland....	262,500	„	

GREAT BRITAIN.

From the preceding table it will be seen that our country occupies by far the highest position in point of production, our out-put being about equal to that of all other countries together. There is, however, no doubt that we have developed our resources much more thoroughly than other countries, and that though our coal fields could maintain their present out-put for 1040 years, yet some of our coal deposits will be worked out long before that time. To this approaching exhaustion I would now direct your attention, as it has a most important bearing on the prosperity of the districts affected, and the general welfare of the country. Even in the next century it will tell against the industries of Scotland and the North of England.

To begin with, take the Scotch coal field, of which the production in

1876 was 18,665,552 tons
and in 1868 „ 14,709,959 „

being an increase in eight years of 3,955,593 „ per annum.

The production is likely to be still further increased as the coal is easily and inexpensively worked, deep pits are unknown in Scotland, and the demand for manufacturing and domestic purposes must increase with the rapid growth of the population and extension of manufactures.

We naturally ask what is the supply. The Royal Commission in their 1871 report, give 9,843 million tons as the quantity of available coal in Scotland; now after deducting what has been extracted since that date, we find the present out-put can only be maintained 500 years. Probably in a century and a half a great diminution in the out-put will be apparent, which will exercise a very prejudicial effect on the prosperity of the South of Scotland.

We next come to the coal field of Northumberland and Durham, unequalled for the quality of its coke and the natural facilities which its rivers afford for the export of coal. Its annual production, 32 million tons, almost equals that of the United States or Prussia, while it surpasses that of all other countries put together. In the last eight years its increase has been rapid, upwards of one million tons per annum.

Out-put in 1876	31,991,623	tons.
„ „ 1868	24,394,167	„
Increase.....	7,597,456	„

The quantity now available is probably about the same as in Scotland, and at the present rate of production will last only some 300 years. In consequence of the great depression in the iron trade, the production last year was a little less than in the previous one, though there is every probability that the out-put will be well maintained for many years. In 50 years, this district will not be able to retain its present proud position of largest producer among the coal fields of Great Britain, and in two centuries coals may regularly be sent from Yorkshire to the iron works in Durham. The waters of the Tyne and the Wear will then no longer be darkened by fleets of colliers, waiting to convey the black diamond of the North to all parts of the world, for the export trade will be gone.

The South Staffordshire coal field is already half worked out, but, lying in close proximity to other more extensive coal fields, its ironworks and manufactories can be supplied on reasonable terms; and though its day of cheap coals is over, its industry is not threatened with a short supply of fuel for many years to come.

The coal fields of Lancashire and Cheshire can probably maintain the existing out-put for 800 years, as, besides the visible, there is a large concealed supply. Looking, however, at the vast and increasing industry of the district, we cannot boast of any too large a supply of coal.

Having considered our best-developed coal fields, let us now examine where the greatest future extension of mining enterprise is to be looked for; and first is the South Wales basin, containing probably 32,000 million tons, or one-fourth of the whole available supply of coal in Great Britain, its out-put being at present but one-ninth. Abuting on the sea coast, and with convenient ports of shipment, South Wales will at no very distant time take the lead in the export trade which the Northumberland and Durham district does at present, and the era of cheap fuel will probably last longer there than in any other part of Great Britain.

Equally bright is the future of the great coal field of Yorkshire, Derbyshire, and Nottinghamshire, with an available supply of 41,000 million tons, or nearly one-third of the whole supply of the United Kingdom. This abundance of excellent fuel must rapidly increase the manufacturing industry and prosperity of this district.

Amongst the smaller coal fields, those of the North Staffordshire district and Bristol probably admit of great development.

Germany.

The production of coal has increased more rapidly in Germany than in almost any other country, and it now

nearly equals that of the United States. To the west, the largest coal field is the basin of the Saar, with an area of some 900 square miles. As yet, however, the out-put is but small.

In point of production, by far the most important are the great coal fields of the Rhine, Ruhr, and Westphalia, yielding together about one-half the whole produce of Germany.

In 1876 it was	17,902,412	metric tons coal *
And	100,124	,, brown coal *
Total....	18,002,536	

This coal is of very superior quality, it can generally be more cheaply mined than either Belgium or French coal, and, but for its distance from the sea, would be a serious competitor of ours in the foreign trade. Several collieries on the Ruhr are already sending quantities to the London market, and efforts are being made to establish shipping ports on the North Sea.

At Piesburg, near Osnabrück, to the north of the last-named coal field, a fair quality of anthracite coal is found. It is but little worked or appreciated at present. There seems, however, to be a great future for it in the supply of the numerous steamers at Hamburg and Bremerhaven, to which it is the nearest coal field.

The coal fields in Silesia are the next in importance, they have a large area, and had an out-put

In 1876, of	10,618,379	metric tons coal *
And	440,488	,, brown coal *
Total....	11,058,867	

Then follow the coal fields of Hanover, Hesse Nassau, and Saxony. The total production of Prussia for the year 1876 being

34,466,249	metric tons coal *
9,985,122	,, brown coal *

* Zeitschrift für Berg Hütten, etc.

Some three-fourths of the brown coal is the produce of the district of Magdeburg and Merseburg, in Saxony. About one million tons are, however, raised in Brandenburg.

Austria.

The largest deposits of fuel are found in Bohemia, where there are important beds of coal and lignite, at present worked on a small but rapidly increasing scale. In Moravia, on the banks of the Oder and its tributary, the Ostrawitza, and also in the districts of Rossitz and Oslawan coal mining is extensively carried on. Coal is also worked in Austrian Silesia.

Belgium and France.

The Belgian coal fields unite with those of the north of France to form one field with an area of some 1200 square miles, commencing at Aix-la-Chapelle in Prussia and running through Liege Charleroi and Mons, in Belgium, it enters France at Valenciennes and continues thence *via* Douai and Lillier to Boulogne.

The Belgium portion of this field is pretty well developed and may be divided into—

1st. The Mons basin producing a good coking and gas coal, chiefly sent to Paris.

2nd. The Charleroi basin intermediate in quality between the last and the next.

3rd. Liege basin, free burning coal.

The French portion probably admits of the greatest future development, but the expense of mining consequent on the contorted nature of the beds and the limited area will never allow of any great out-put.

Further south lie the coal fields of the Loire and St. Etienne of limited area but with a large production. As compared with other countries of Europe, France has but small wealth in coal.

Spain.

In addition to her other great mineral wealth, Spain has large coal fields, and though at present but little known and with a very small production, they are at some time destined to be of great importance.

An excellent coal is now worked in the Linares district in the South where it is used for iron manufacture and lead smelting and is said to be equal to the best English coal.

Perhaps the most important deposits of coal are found in Asturias and extend along the Bay of Biscay from Santander to the west. The quality of the coal is good, there are several excellent harbours along the coast which will serve some day as convenient shipping ports, further, there is a great abundance of superior iron ore. These advantages must in time make this one of the greatest coal and iron producing districts of Europe and probably an important rival of South Wales.

In the north-east of Spain and some other districts small deposits of coal are known.

Russia.

The carboniferous rocks are extensively developed in Russia, and at intervals contain valuable coal beds; the most important of which is probably the coal field north of the Sea of Azof, between the Dnieper and the Don, with an area of about 11,000 square miles. The great natural advantages it possesses in its proximity to the sea coast will enable it some day to supply the trade of the Black Sea, and the navigable rivers which intersect it will afford an easy and cheap transport to the interior of Russia whenever its resources are developed. In fact, this coal field, which is at present mined in a very rude manner in a few places only, appears destined at some future time to become the centre of a larger manufacturing industry than any other part of Russia, for we have

here the singularly felicitous combination of abundance of coal and corn, cheap water transport, central position between the markets of Europe and Asia, together with a less severe climate than other parts of the empire. If a spirit of enterprise and industry could only be implanted in the people it would soon take a foremost rank in Europe as an industrial and commercial centre.

Another large coal field stretches along the western base of the Ural Mountains from the Arctic Sea to the River Ural. In time it must be of great value as a source of fuel for smelting the rich ores of iron and more precious metals so abundant in these mountains.

There are extensive coal fields in the centre of Russia around Moscow, but the quality is poor. In the Causcasus is also a deposit, while in Poland is a small but very productive coal field on the confines of Austria, Prussia, and Russia, remarkable as containing a very thick coal seam, no less than 16 yards in thickness.

Turkey.

Some valuable beds of coal are found in Moldavia, Roumelia, and on the Black Sea, the extent is at present almost unknown, but under a better form of government they will no doubt be rapidly developed. Near Erakli, on the Black Sea, coal was mined during the Crimean War, for the use of the combined English and French fleets.

In Styria, Northern Italy, Switzerland, and even in Greece, deposits of lignite are pretty extensively worked, but from the inferior nature of this fuel, it will never have more than a local consumption. A little anthracite is mined on the Alps, in Savoy, and Canton Glarus.

In conclusion, I have to acknowledge the assistance I have derived from Professor Hull's work on the Coal fields of Great Britain.

The PRESIDENT said he believed it may be taken as a fact, as stated by Mr. Johnson, that ordinarily the best coke came from the North of England; but there are cokes manufactured in Lancashire which would hold their own against the best Durham coke, and, by care in the manufacture, actually fetched higher prices. Coke might be made silvery or black in appearance, light or heavy, according to the treatment it received in the oven and on coming out of the oven. Of course there must be a suitable coal for coking.

Mr. JOHNSON, in reply to observations made by Mr. Martin, said that in his opinion, the Westphalian coal field would never be anything more than, say that of North Durham and Northumberland. It would be a number of years before it overtook them. It would not compare in area with the Russian coal field, say in the neighbourhood of the Sea of Azoff, and he believed some of the Bohemian coal fields would develop quite as largely as those of the Ruhr were developed at present. A great deal of money had been laid out there, and a great impetus given to industry through the development of the iron trade.

Mr. MARTIN said he had omitted to mention that the director of one of the Government mining schools estimated the coal fields of Westphalia, as already explored, to contain coal for 800 years, at the present total out-put of Great Britain. The Brown coal of Bohemia was quite a different article to the so-called "Stone Coal" of the Carboniferous measures, and is not likely to compete with it generally for industrial purposes. It is unsuitable for iron manufacture on a large scale.

Professor BOYD DAWKINS said he wished to say a word regarding the production of coal in this country. It seemed to him that the statistics regarding our ultimate supply of coal were altogether unsatisfactory. It was, undoubtedly, true that we had a certain area of coal cropping out at the

surface, which we could estimate certainly, and about which there could be no mistake, but to this must be added the coal which was under the red rocks, and the probable extent of the valuable and important coal measures of South Wales, in Somerset, and of Yorkshire, under the secondary rocks of Southern and Eastern England. He thought it extremely probable that, as enterprise got developed, we should find coal to a larger extent than was at present suspected. He would not be surprised at their finding enormous supplies of coal under the South-eastern districts of England. It is true that the exploration in the Weald, near Battle, failed, but everybody knew that to sink a shaft for the coal measures under the secondary rocks was like letting down a line to fish in the sea. They did not catch a fish, but he had no doubt that, if some half dozen or so further attempts were made, one or more would be successful. He believed they would hit the coal field, so important in South Wales, which cropped up in the neighbourhood of Bristol, and was really a continuation of the important and valuable field which extended through Belgium into the region of Westphalia. With regard to the general question of the supply of coal, he could not help believing that the enormous fields in the United States contained by far the largest supply of coal of any part of the world. He looked upon that region as the ultimate centre towards which all enterprise would gradually converge.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVII. VOL. XIV. SESSION 1877-8.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 26th February, 1878, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., President,
in the Chair.

Mr. Charles Cooke, manager of the Moston Colliery, Failsworth, was elected an Ordinary Member of the Society.

THE MINES OF THE PARYS MOUNTAIN, ANGLESEY.

The following paper "On the Mines of the Parys Mountain, Anglesey," was read by Mr. T. F. EVANS, H.M. Inspector of Mines:—

The voyager who sails along the Northern Coast of the Isle of Anglesey cannot fail to have his attention attracted by an object lying about two miles from the shore, which, from its barren and singular appearance, contrasts conspicuously with the fertile pasture lands of the surrounding country. It is a little hill, which, although rising no higher than about 500ft. above the level of the sea, and bearing over a large portion of its surface a soil deep enough for the

support of a vigorous vegetation, is yet almost entirely destitute of a blade of grass, a bush of gorse, or even a sprig of heather.

This is the little eminence once rendered famous throughout the world, under the name of Parys Mountain, by the enormous quantities of copper ore annually extracted from its southern slope. Its mines were in modern times first successfully opened in the year 1768, and from that time up to the present day they have been prosecuted without cessation. Although subject, like all mining enterprises, to alternations of richness and poverty, and frequently adversely affected by mercantile depression in their staple commodity, they have maintained their existence with a tenacity which can be explained only by the huge development of the orey masses and the general regularity of their method of occurrence.

A reference to the map of the geological survey will show that the subject under treatment is situated a little less than two miles south of the town of Amlwch, within but close to the northern boundary of a band of shaly slate of the Silurian age, which stretches almost across the island in a south westerly direction from Dulas Bay to the sandy shore known as Tywyn Trewan, and throws out about the middle of the island a small branch which takes a north westerly course, and enters the sea at Carmel's Point. The area lying to the north of this band is composed chiefly of chloritic and micaceous schists apparently of the Cambrian age, but containing, at Llanbadrig and other neighbouring spots upon the coast, beds of rock of small extent, which supply evidences of being Silurian.

South of Parys Mountain, a band of slaty shale trends from east to west, and beyond this, southwards, a belt of granitic and gneissic rocks observes the same direction.

Coming to Parys Mountain itself, it may be described geologically as lying in the narrow band of Silurian rocks before referred to as traversing the isle of Anglesey.

The limit to which these remarks are of necessity confined, precludes a minute description of the structure of the hill, which might possibly be made interesting if time allowed; but for the purposes of the present paper it will be sufficient to describe it as consisting of five great rock masses of which its general mass is composed. These are 1. The northern slope, consisting of slaty shale, in which occur veins of small extent both as regards breadth and length of quartzose and felspathic rocks with occasional bands of a greenish rock, which I think may be correctly described as a variety of phonolite. 2. A huge vein of quartz, which runs from one end of the hill to the other, forming as it were its natural backbone, and known to the miners as the Carreg-y-doll lode. 3. A great mass of felspathic rock, which varies considerably in colour and character in the course of its length and breadth. 4. A band of slate of a deep blue colour, and 5. A second band of felspathic rock, very similar to the first both as regards character and extent, which underlies the whole of the rock masses composing the mountain. Fig. 1 on the diagram will serve to explain their order of sequence.

The Slaty Shale is of a nature and colour which belong characteristically to the Silurian slate formations. The quartz taken generally is true vein quartz, but in some places it undoubtly assumes the condition of quartzite.

The felspathic rock underlying the quartz is somewhat more difficult of description than the rest, and I suppose I may for that reason be allowed to quote a high authority while making the attempt. In referring to these rocks in the Memoirs of the Geological Survey, Ramsay, remarks:— "It is a difficult matter to name or decide on the origin of "the the hard masses that are associated with these shales." He says it resembles in some places the finely bedded felspathic ashes of Carnarvonshire, the unsedimentary felspathic mass of Snowdon, and the felspathic substance that enters

into the composition of lodes near Penmachno. I would venture to add an opinion, the result of observations made over an extensive area, that these rocks are of the same age, orgin, and character, as those great masses of rock styled by Ramsay, felspathic ashes, volcanic conglomerates, and contemporaneous felstones found intercalated with the schists in a very large proportion of the area of Silurian system. The beds of hard rocks which interlie the great slate veins of Festiniog, and termed by the Welsh slate miners "*Gwenithfaen*," are in many places identical in appearance with the rock-masses now under notice, and there is probably not a rock in the neighbourhood of Festiniog and the country lying some miles to the north of its slate mines, of which the analogue may not be found in the narrow strip of Silurian rock in which our subject occurs. The slates and schists also resemble each other so closely in both places that those veins which have been cut at a great depth in the mines of Anglesey, would have furnished a supply of excellent roofing slate, but for the adventitious presence of metallic ores which decompose on exposure to the atmosphere.*

Parys Mountain may, in fact, be regarded as an outlying piece of ground, geologically identical with the region in which the great slate mines of Festiniog occur, and from which it differs only in being developed on a much smaller scale, and in being highly metalliferous.

The narrow band of cognate Silurian rock in which it is situated was probably deposited at the bottom of an ancient sea contemporaneously with the great corresponding tract of Welsh mainland, and the areas of the same formation exist-

* In driving south some years ago in the Mona Mine, a vein of slate, of great width, was cut, which turned out, even in the area of a drift of seven feet by five, slates of a large size, and of excellent quality and colour. It is yet a question how far this discovery might be made profitable.

ing in Cumberland and North Lancashire, the Isle of Man, and probably the South of Ireland.

The map of the Geological Survey gives us a very correct notion of the geological formation of the mountain; but, the scale being small, there are of course features of detail which can only be described by a paper devoted specially to the subject.

Referring, then, to the sectional sketch given previously, I now propose to give a ground-plan which will serve to illustrate the disposition of the rocks on the surface and the general structure of the hill. See Fig. 2.

As shown by this sketch the rock masses are traversed at right angles to this strata by two faults termed by the miners *the Great Cross Course* and *the Carregydoll Cross Course.* The latter is a mere transverse cleft, which has had hardly any effect upon the relative positions of the rocks forming its sides; but the Western or Great Cross Course is on the contrary of considerable width—varying from twenty to sixty feet—it is filled with mixed and broken masses of the neighbouring rocks, and has greatly disturbed the otherwise regular and almost continuous strata.

An examination of the two sections presented by this fault, leads one to the conclusion, that it is the result of the vertical force which produced the Parys Mountain, and that the extensive heave thus shown was caused by an upheaval and not by a horizontal movement. This may, perhaps, be best illustrated by the sketch Fig. 3, the upper line being intended to represent the section elevated by upheaval, and the lower the original level. The dotted lines in the lower section indicate the northern heave of the inclined formation of which the elevated section is composed. Denudation has removed the uplifted mass to such a degree, that the surface now presents only a gentle rise at the line of rupture, and the rocks composing the western end of the detached central block, owing to their

dip of 45° have the appearance of having been thrown north about 360 feet, thus indicating a vertical elevation of the same extent.

Excepting the great vein of quartz referred to, the strata of hard rock may conveniently, and, as I believe correctly be designated felstone. They vary greatly in colour and character in different places. In some places where they abut against the shale, they are of a deep blue colour, obtained apparently from the neighbouring rock; in others they are tinged with reddish ferruginous streaks, while as they approach the great quartz vein, they assume first a delicate buff colour, and then become gradually whiter.

In the dislocated central block lying between the two cross-courses the felstone shows signs of disintegration, which are not discovered in other portions of its course.

The felstone here in many places consists of a soft concretionary mass, which contains to so great an extent small nodules of a conchoidal form that the miners have applied to it the name of "*Carreg-y-Grogan*, or "*Shell Stone*." In these nodules kernels of copper pyrites—the prevailing metallic ore—occur so largely that this ground has formed one of the most profitable resources of the mine in which the formation occurs.

The phenomena here presented are of a nature to deserve the attention of all geologists, and the effect which the disturbance appears to have exercised on the metalliferous veins will be the subject of remarks which I propose to make later on in my paper. I would, however, beg to submit to my hearers the question whether the disintegration here occurring is not of the same nature as that which takes place when the builder takes a stone from a quarry and inadvertently, or in ignorance of a well-known rule, places it in a position different from that in which it was formed.

Coming to the metalliferous deposits, which, while rendering for a long period the small patch of ground in which they occur one of the most profitable in the world, have at the same time led to explorations of great value from a geological point of view I may briefly explain their mode of occurrence to be as follows: beginning at the north, a large lode of copper pyrites, associated with a matrix consisting of quartz and slaty shale, and known as the *North Discovery Lode*, extended from a few fathoms west of the *Great Cross Course* to a distance of about 90 fathoms westward. This orey deposit partook more of the character of a *lode*, as that term is usually understood by miners, than any other important formation discovered in these mines. It was well defined, hard slate rock as heading and hanging walls, and differed from the other neighbouring so-called lodes by dipping at an angle of 60 deg., according to Mr. C. B. Dyer, the late able manager of the Parys Mine, who says that the orey deposits contained in the lode *dipped or shot* west at the rate of 3ft. in a fathom. It was also distinguished from the others by the almost entire absence of felstone or felspathic rock. This great lode has now been almost entirely worked away, after producing, during recent years, copper ore to the value of close upon, if not over, one million pounds sterling.

With the exception of some small quartzose strings containing copper pyrites and small streaks of galena and blende, which have not as yet been found to include any metalliferous deposits of economic value, the next lode is the one previously styled the *Carregydoll Lode*, a name said to have descended from a date long anterior to the present working of the mines, and supposed to signify the rock at which toll or tribute of ore was taken at a very remote period.

This bed of quartz, which varies from 5ft. to 60ft. in width, contains in some places "bunches" of copper pyrites

of great extent, which have from time to time been profitably wrought. It contains also iron pyrites but not so abundantly as the rocks lying to the south. In driving along its course dressy *caples* or *locks* are occasionally met with, which, when entered with a candle, display a scene of intense brilliancy.

One of these encountered a few years ago was no less than eight fathoms deep and from three to four in height. The ore in this lode occurs in patches, which, like the orey deposits in other parts of the same ground, appear to have a tendency to shoot or dip towards the west.

The large felspathic mass underlying the *Carregydoll lode* contains also great deposits of copper pyrites, the ore being, as a rule, mingled with it in the form of strings, varying in size from a mere washing on a jointy facing to embedded veins and bunches, which sometimes assume the form of beds of several feet in magnitude. This ground has been the source of large profits, and extensive orey faces, now standing idle, would return enormous quantities of copper ore if the price were sufficiently high to make the working remunerative. Extensive and important as these deposits may be, those which occur to the south of the felspathic band now under notice, and lie immediately between it and the shaly slate marked *a* in the plan and section, are by far the most interesting to the geologist and the most important to the miner. At this plane of juncture two enormous excavations, termed opencasts, may be said almost to cut the mountain in two. In the course of their length they vary in depth from 18 to 23 fathoms, and following the strike of the strata occupy a surface area computed at a little more than 12 acres. They are bounded on the north by the felstone just now described, and on the south by the band of shaly slate, which occurs between the two parallel strata of felstone. At this point occurred the great body of copper ore which once exercised as powerful an influence on

the copper market as that obtained in the present day by the importations made from the mines of Chili and South Africa. The ores were comparatively poor: they contained, on an average, not more than from five to six per cent. of metallic copper; but, as there was not for the time a limit to the quantity the mines could be made to produce, the owners held the copper market almost entirely in their own hands. This is a condition of prosperity which has long passed away, but as history repeats itself even in the case of mines, and as the ore-bearing ground of this fertile tract has as yet been but partially explored, the time may yet arrive when the mines will once more enjoy their ancient importance.

The metalliferous mass worked here may be described as occurring as follows:—

1. A bed of iron pyrites lying on,
2. A bed of copper pyrites, and occasionally
2. A huge bed of an ore locally known as Blue Stone, which, by the analysis of Mr. C. H. Hills, of the Amlwch chemical works, contains:—

Lead	11 to 13 per cent.
Zinc	30 „ 32 „
Iron	14 „ 16 „
Siliceous Gangue ..	16 „ 18 „
Sulphur	24 „ 26 „
Copper	½ „ 1 „

with 10 to 14 ounces per ton of silver and 2 or 3 dwts. of gold. See Fig. 4.

The iron pyrites and copper pyrites are invariably mixed with felstone and quartz, but the blue stone is much purer and contains only strings and nodules of apparently pure quartz. It is purest where it intermingles with the underlying shale, when it occurs as elliptoid wedges, which interchange with similar portions of the enclosing rock. The bed of this mineral, which underlies the other ores varies greatly in extent, being found, in one place, of a thickness of 50 or

60 feet, while in others it is reduced to a vein of a few inches or even entirely disappears. Very large quantities of it might be raised, but the profitable separation of the metals it contains having so far baffled the most ingenious metallurgists, the mineral now remains almost entirely unwrought.

The beds of pyrites and blue stone appear to thin out as they descend, while the copper ore becomes freer from impurities, and consequently richer in produce. Reverting to the elevated central block lying between the two Cross Courses, and to the decomposition there occurring in the felstone, I would here introduce a subject which has imparted to these mines a character in which they may be said almost to stand alone. Not only do the felspathic and other rocks contained within its area, exhibit disintegration, but the metalliferous deposits there occurring have been and are undergoing a process of decomposition, thus exercising upon the mines an effect which may be termed highly important, both geologically and economically. As previously stated, the surface at this part has been excavated to a considerable extent, and the original configuration of the surface can therefore be only guessed at from the surrounding edges. These edges would lead one to the conclusion that the original surface consisted of a ferruginous substance termed by the Cornish miner *gossan*, which in some places was an ochre of various shades of yellow and red, and in others a cindery crust presenting a beautifully iridescent surface, which contained bands of the sulphate of lead, and on its exterior well defined crystals of the same mineral in the form of Anglesite. The sides of these open-casts thus present a variety of brilliant colours, which render them an object of singularly gay appearance in the strong light of a clear day. Going lower down, we find the so-called lode presenting every appearance of decomposition. The felstone has become a soft mass previously termed shelly, small

strings of quartz occurring here and there have become as porous as pumice from the decomposition of the copper and iron pyrites they once contained, the heading shale has become a soft mass of clay, while the water issuing from the ground is a strong solution of the sulphates of copper and iron. The waters of these mines contain generally a considerable quantity of the two sulphates, but it is in the part now referred to that they are strongest by far, and it is, I think, a question whether the waters rising here do not, in percolating through other parts, induce a decomposition which would not have occurred but for their presence.

The water is raised by means of wooden pumps—iron, as will be readily understood being utterly useless under such conditions—and when brought to the surface it is stored in reservoirs specially prepared for its reception. Here it deposits all the small particles of clay and grit which it acquires in its course, and having thus become clear it is tapped off as required into the tanks in which the precipitation of its copper is effected. This process may thus be briefly described:—

Rectangular tanks are prepared in brickwork, which have a bottom of undulating form. See Fig. 4.

These tanks are filled with old iron, consisting of old tinned utensils, old cast iron, and every kind of scrap, and the cupreous water is allowed to flow first into the head "pit," and from it continuously through a series which is lenghtened or shortened as found necessary with the varying strength of the water passing through. Four times a year the precipitate thus obtained is collected in the following manner: The water is first drawn off, all the iron is then placed upon the "backs" of the wavy bottom, and the copper attached to it is washed away by throwing violently against it by means of scoops the water still remaining in the hollows. This process accomplished, the precipitate is allowed to subside, and the clear water is drawn off by

taking out plugs (shown in the section) placed in the middle of each trough. The precipitate is then carried in casks to a pit where it gradually acquires the consistency of soft mud, and is then taken to a reverberatory furnace where it is dried and made ready for smelting.

The water thus treated flows afterwards into large reservoirs, some of which have an area of several acres, and there by a natural process, familiar to chemists, deposits a sediment of sub-persulphate of iron, known commercially as precipitated yellow ochre. Some thousands of tons of this article are annually sold. It is used largely as a gas-purifying material, and considerable quantities are calcined for the production of the various iron oxide paints and Venetian red. These mineral waters must have issued from the ground for a very long period, for South of the mountain there is an extensive peaty tract, many portions of which are cupreous, while others contain so much ochre as to produce excellent gas-purifying material. When the price of copper was high, the cupreous peat was burnt on a large scale, and the ashes thus obtained, containing from 2 per cent. to 4 per cent. of metallic copper were smelted with the other ores of the mine.

The streams of water proceeding from the mines are of a deep port wine colour when first pumped out, they gradually become lighter in colour as they deposit the ochre; but even where they enter the sea, they impart to it a yellow tinge, which sometimes stretches out a mile or more into the channel.

In former times the copper ores raised at the mines were calcined in huge heaps upon the mountain, the sulphur thus expelled being saved in long brick chambers, termed "receivers," and afterwards sold. This mode of calcination was exceedingly cheap—no fuel being used—but it was very slow, and necessitated the holding of large stocks, and it has

ıow for some years been discontinued as unprofitable,* the ulphur the ores contain being used in the manufacture of ulphuric acid by the Messrs. Hills, whose chemical works ıre at the neighbouring port.

The ores raised here were formerly smelted into fine ›opper, of which from 500 to 800 tons were annually sent ıway, but the increasing price of coal, and the enhanced ralue of labour, rendered it necessary a few years ago to imit the smelting operations to the making of regulus only.

Having thus given a general description of the mines and ihe operations therein conducted, I would, as my paper lraws towards its close, turn once more to the remarks made ıpon the petrological structure of the hill, and beg leave, with unaffected hesitation, to submit to you a theory, as to .ts formation, which has been forced upon my mind by years ›f daily observations made in the mines both underground ınd at the surface. I have long been convinced that the felstones are not intrusive and do not owe their present form to igneous agencies. How then, it may be asked, is iheir presence to be explained? The limit to which this ›aper is of necessity confined precludes a lengthy statement ›f my views, and I fear I may, for that reason, lay myself ›pen to the charge of asserting dogmatically, but can assure you that, were the matter to become the subject of compre-ıensive discussion and argument, I think I could adduce facts which would be admitted go far to uphold my theory, f not to prove it completely.

The felstone, the quartz, the slate, and the metalliferous leposits are beds or veins formed by segregation. Their ıistory may thus perhaps be correctly stated.

A sediment was deposited at the bottom of a Silurian sea, into which flowed a stream of water containing, like that now

*The sulphur escaping from this operation caused the sterility of the hill noticed in the opening part of my paper. The vegetation it once bore was so completely eradicated by the fumes that it shows hardly any signs of recovering its former traditional clothing of pasture, gorse, or heather.

issuing from the mines, certain sulphates in solution. These sulphates became converted into sulphides in the presence of decaying organic matter, and the whole mass became solidified in the form of horizontal strata of the same nature probably as the Kupfer Schiefer or copper slate now worked in Germany.

Another operation, arising from the mutual attraction of particles of the same mineral for each other, now began, which ultimately brought together the various substances previously distributed generally throughout the mass. Hence arises the uniform regularity of the strata in strike, dip, form and order of succession, a regularity which is no less characteristic of them than of the far larger analogous masses occurring in Carnarvonshire and Merionethshire, and which may possibly receive an explanation by our electricians. The only difference is that in the corresponding felspathic rocks of Carnarvon and Merioneth, metallic ores are but rarely found, and are never more than mere valueless strings. If this theory is correct, these great rock masses should no longer be termed igneous, and ought instead to be designated huge segregated strata. I am well aware that in framing this theory I am running counter to the views of our most eminent geologists, and having a full appreciation of the importance of the question, nothing but a conviction of the soundness of the views enunciated would have induced me to lay them before you. I hope the remarks I have made may be the means of drawing to the subject the attention of more skilful geologists than myself, and thus, as I confidently expect, hasten the day when the terms igneous, volcanic, and intrusive shall cease to be applied to a single rock mass in the Silurian and Cambrian formations of Wales.

Mr. EVANS said it was almost impossible that a subject which was merely of local interest should attract much attention among a Society of geologists in Manchester; but

ıere was one matter which he had referred to—the theory hich he enunciated in the concluding part of his paper—pon which he would be very glad to hear the opinion ? any geologists present who might know anything of ıe subject. He had studied it very closely for a long me, and if he was right—he spoke very humbly—he ıought that theory would exercise a very great influence ıdeed upon the future of geological science.

The PRESIDENT said that a few years ago it was, he ıought, much more commonly held than at the present me, that many of those rocks were due to igneous ;tion. The Germans were, perhaps, the first who took the ɔposite view, and a great number of British geologists had ıllowed. Many of the so-called igneous rocks undergo such change upon being subjected to heat that he never could imself understand how they could be reconciled as being ue to the action of fire. For instance, the peroxide of iron non-magnetic, but immediately on being exposed to a very ıoderate heat it becomes a magnetic ore. There were many ;her similar tests which would show that the action of fire had ever operated upon these ores or rocks. In a paper like [r. Evans's it was possible only to lay hold upon one or two ɔints, as they were read; but he had been struck with the ;ratification in the vein, the iron pyrites being on the top, ıen the copper lying underneath, and the bluestone, which ad been described, below all. He did not know whether Mr. ;vans could give any explanation of that—whether it was ue to specific gravity or any other cause; but, perhaps, aving seen the ore *in situ*, he might have come to some ɔnclusion upon it. It also seemed to be very regretable hat such a large mass of ore as that described—the blue-tone—should remain practically unworked, on account of he specific gravity of the different minerals of which it is ɔmposed being such as to interfere with the separation of ;rom each other. It was many years ago since, at mines in

Belgium, he had seen a similar mixture of ores, when the ordinary water process failed, separated by means of air. They had a long pipe, small at one end and gradually increasing in diameter; and when a current of air was passed through this the velocity of course decreased as the air got into the wider part, the effect being that some of the ore, which was finely powdered, fell in the stronger current, whilst the lighter was carried further by the slower current.

Mr. MARTIN suggested that when Mr. Evans's paper was printed the members should have an opportunity, at a future meeting, of giving their views upon it.

Mr. EVANS said, with regard to the order of sequence of the copper pyrites and blue stone, he had merely to state that such was the order. What the law might be which was involved in it, he was utterly unable to explain, but it was probably the same law which had arranged the order of sequence of the non-metalliferous mineral names with which they were associated. It occurred not only in the Parys Mountain, but could be found existing uniformly throughout nearly the whole of North Wales. Then as regarded the nearly the whole of North Wales. Then, as regarded the treatment of the blue stone, he quite agreed with the Chairman that it was very much to be regretted that no process had yet been invented for treating that mineral successfully, but he could at the same time assure the meeting that it had received the attention of very competent metallurgists. The separation of the mineral it contained had been tried mechanically in an infinite number of ways, also chemically by a variety of processes, but so far it had never proved successful—at least never profitable, except when the price of zinc had been exceedingly high, and the spelter obtained had paid for extraction. Seeing that the mineral was worth no less than £5 to £7 per ton, according to the varying markets, it was, as the Chairman observed, very much to be regretted that it could not be profitably treated.

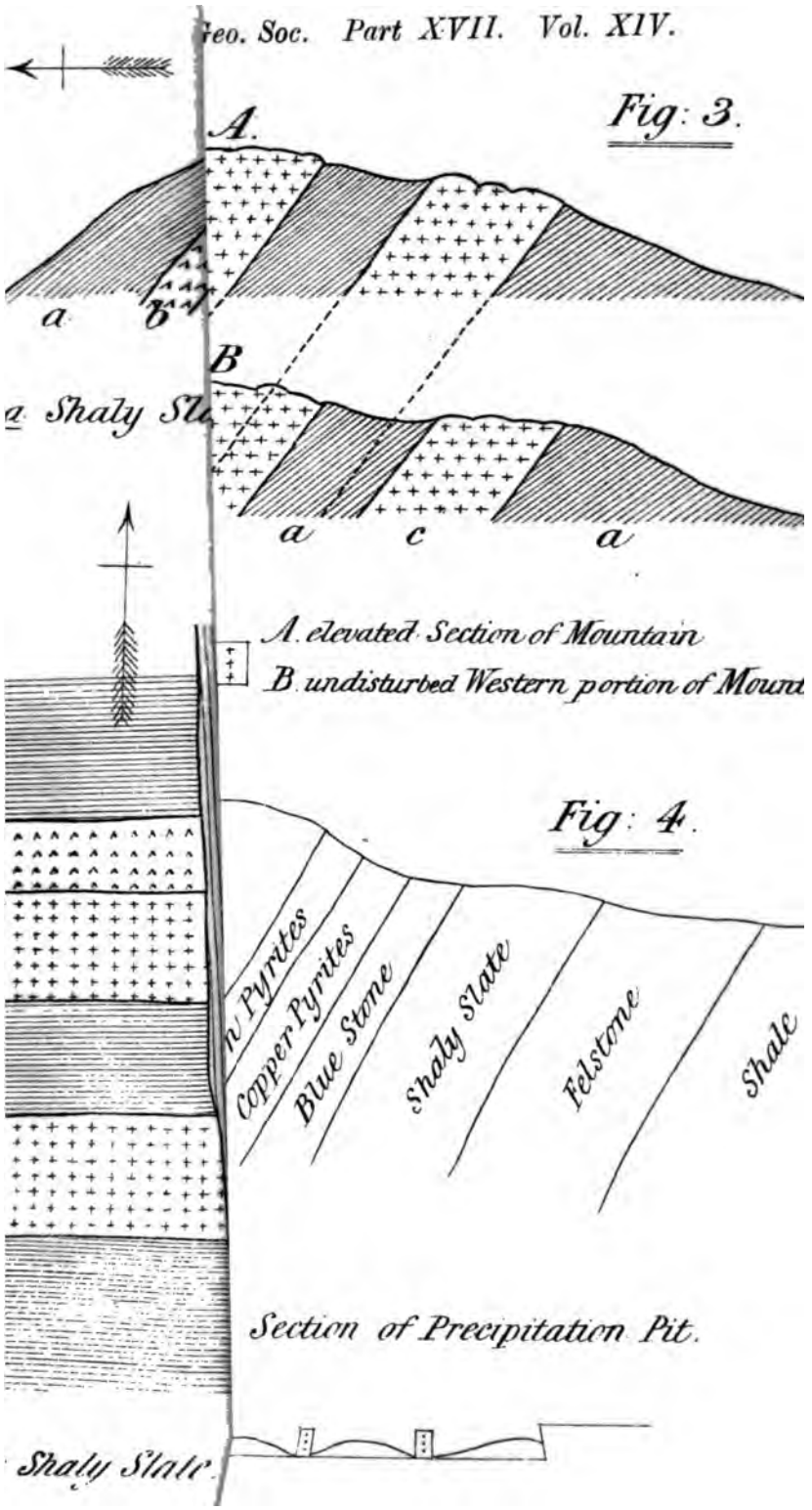


Fig: 3.
A.
a
b
B
a
c
a
Shaly Sla
A. elevated Section of Mountain
B. undisturbed Western portion of Mount
Fig: 4.
n Pyrites
Copper Pyrites
Blue Stone
Shaly Slate
Felstone
Shale
Section of Precipitation Pit.
Shaly Slate

Belgium, he had seen a similar mixture of ores, when the ordinary water process failed, separated by means of air. They had a long pipe, small at one end and gradually increasing in diameter; and when a current of air was passed through this the velocity of course decreased as the air got into the wider part, the effect being that some of the ore, which was finely powdered, fell in the stronger current, whilst the lighter was carried further by the slower current.

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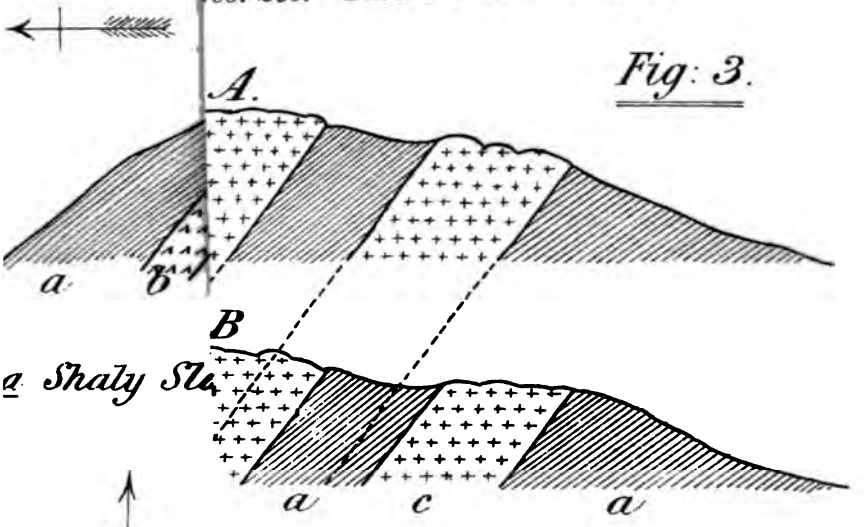
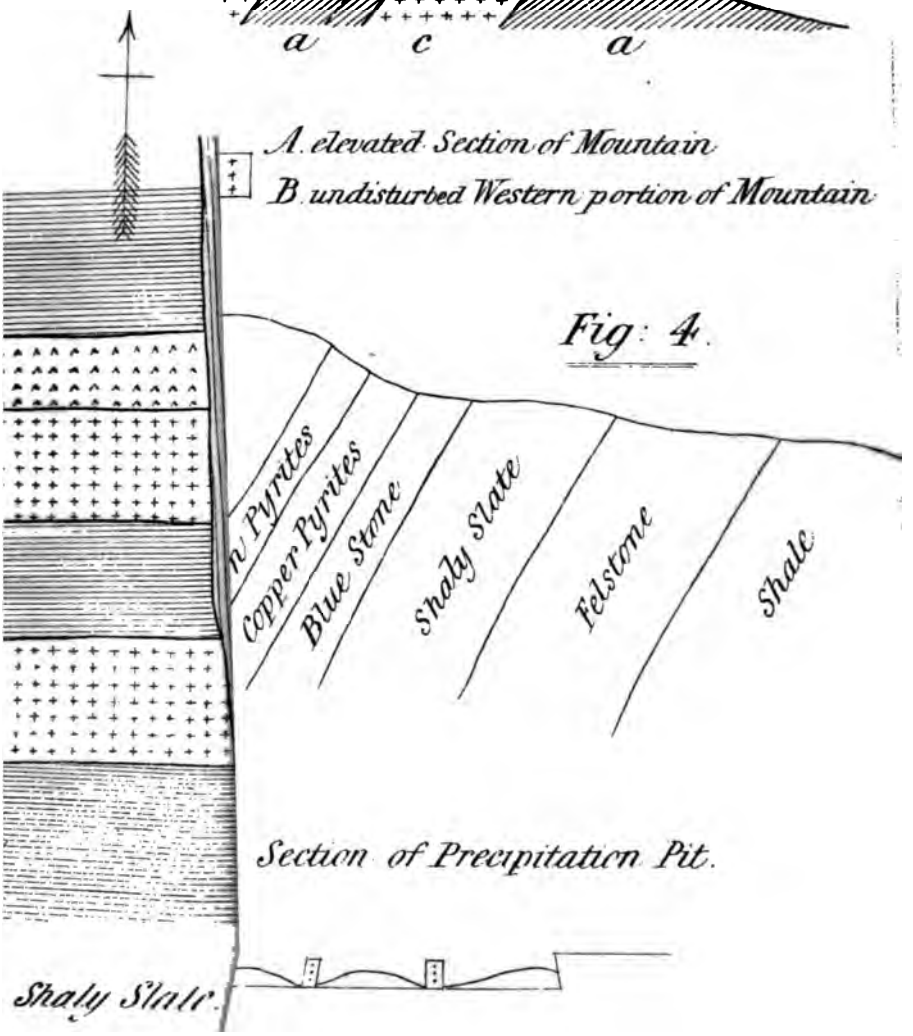
Fig: 3.



A. elevated Section of Mountain
B. undisturbed Western portion of Mountain

Fig: 4.



Section of Precipitation Pit.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVIII. VOL. XIV. SESSION 1877–8.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 29th January, 1878, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., President, in the Chair.

The undermentioned gentlemen were elected Ordinary members of the Society, Mr. T. F. Evans, Mona Lodge, Amlwch, Anglesey; Mr. H. T. Cowburn, West Leigh; and Mr. Samuel Ogden, Werneth House, Oldham.

PEBBLES FROM THE COAL.

Mr. W. J. GRIMSHAW, F.G.S., exhibited a rounded pebble from the upper bed of the Three-yards coal at Radcliffe. It was, he stated, found pretty nearly in the centre of the seam; and no other specimens of the same description had been found in that seam to his knowledge.

The PRESIDENT: Specimens of the same kind of stone were brought before the Society some years ago from the Roger Mine, at Dukinfield; and also one, I think, from the Black Mine, at Oldham; and one or two from the Trencher

Bone Mine, at Kearsley. But this, I believe, is the first we have had from the three-yard coal at Radcliffe. I considered them siliceous aggregations when I brought them from the Roger Mine, some years ago.

Mr. GRIMSHAW: We have found them in other mines, but usually five or six together.

In the year 1873 or '74 a fire took place at a colliery in Staffordshire, and in order to put it out, the water from an adjoining stream was turned into the pit. On a subsequent examination of the place where the water met the fire, in the shaft level, circular holes were found scooped out in the floor. These holes were filled with fragments of coal which had been angular, but were now rounded, as if by some circular motion—that motion probably having been induced by the contact of the fire with the water. A specimen of the coal was exhibited, rounded as described. The bottoms of the holes, which, in some cases 18 inches deep, were filled with small rounded fragments of that kind, and covered with larger pieces rounded in a similar way.

A paper was read "ON THE OCCURRENCE OF BRINE IN THE NEW RED SANDSTONE STRATA AT WARRINGTON," by Professor EDWARD HULL, F.R.S.

BORING SHAFTS, &c., IN WESTPHALIA.

Mr. J. S. MARTIN, F.G.S., read the following paper communicated by Mons. A. Demmler, Ingénieur, 86, Rue de l'Université, Paris:—

All persons connected with mining are well aware that one of the most difficult operations connected therewith is sinking pits through heavy feeders of water. The great facility with

which bore holes were put down to great depths and cased, long ago induced intelligent miners to endeavour to bore holes of diameter large enough for their employment as shafts. MM. Kindermann & Honigmann, Mining Engineers, of Westphalia, were the first to give the project a practical trial, They bored several holes of about 6 feet diameter, but did not succeed in rendering water-tight the sheet-iron tubbing which they employed. About 30 years ago, M. Mulot, a well-known French Mining Engineer, bored a pit of 11 feet diameter in the Pas de Calais district. He employed wooden tubbing, but also failed to render it water-tight. M. Kind, a celebrated Boring Engineer from Saxony, was the first person who succeeded in boring and tubbing a shaft without pumping. The shaft in question was put down in 1849 at Schönecken, a small village in the (then) French department de la Moselle. The tubbing which he used was very imperfect. It consisted of wooden pipes, hooped with iron at the top and bottom of each length. The diameter of these pipes was 11ft. 6in. inside, and each length was about 10ft. The ends of the pipes were turned in a lathe, and the lengths were simply laid on the top of each other, without any connection at the joints beyond the fitting of the turned ends. The space behind this primitive tubbing was filled up with cement, after the tubbing had been lowered to the bottom. However, the pit could not be sunk through the coal measures, as the tubbing could not be maintained water-tight. The same system was employed unsuccessfully in the sinking of No. 1 pit Dahlbusch Colliery, Westphalia, which was stopped several years while the tubbing was repaired. It still remained very wet, and this system could hardly be considered satisfactory. M. Kind entered into partnership with M. Chaudron, Inspector of Mines in Belgium, and between them such improvements were introduced as rendered the system practically useful. The principal im-

provements consisted in the substitution of iron in place of wood tubbing, and in closing the bottom of the former temporarily, thus rendering the lowering much more easy. From that time many pits were sunk in France, Belgium, and Germany, by the Kind-Chaudron system. The method had, however, several inconveniences. The pit could not be bored its full diameter at one operation, because between two strokes of the chisel, the breadth of the stone remaining was too great on the circumference, and too narrow towards the centre of the pit. Suppose that the angle of two strokes is such that the breadth a, (Fig. 1. Plate 1.) is sufficient for breaking the ground in the middle of the radius; then at the end of the radius the breadth ($2a$) is doubled, and the chisel, being in a straight line, is required to remain very steady when delivering a blow, otherwise the shaft might deviate from the perpendicular. This happened at several pits, the deviation being in some cases as much as 13in. Struck by these and other defects, an experienced French boring contractor, M. E. Lippmann, partner in the firm of E. Lippmann & Co., devised several improvements of the system. A favourable opportunity of submitting his improved methods to a fair trial soon offered. The Gelsenkirchen Coal Mining Company, Westphalia, intending to sink the No. 2 pit at their Rhine Elbe Colliery, the writer of this paper, who was then general manager for the Company, contracted with MM. E. Lippmann & Co. for the execution of that work. No. 1 pit had been sunk by an English contractor and English sinkers under great difficulties, in consequence of the large quantity of water which had had to be contended with. In Westphalia the coal measures are overlaid by marl strata, the thickness of which was 340ft. in No. 1 pit. The amount of water pumped to a depth of 250ft. was nearly 9000 galls. per minute; one feeder alone amounting to 3500 galls. Very powerful pumps (32in. diameter × 10ft. stroke) were employed, still it was

barely possible to sink through the marl. By dint of perseverance and at considerable cost, the greater part of the feeders were tubbed off and the leakage reduced to 50 galls. per minute. The pit was in course of sinking to the coal measures, three years (1857-61), and cost to that depth above £100,000. No. 2 pit was intended to be sunk at a distance of 40 yards from No. 1, through the same strata, and consequently the same feeders would require to be dealt with. The writer accordingly resolved to bore the pit down without pumping, and, as before mentioned, confided the work to M.M. Lippmann. The apparatus employed by these gentlemen may be classed under two heads :—

1ST.—BORING APPARATUS.
2ND.—TUBBING APPARATUS.

The Boring Apparatus comprises the following parts :—

1. *a.* Boring trestle or pulley frame and shed.
2. *b.* Beam and moving gear. (Figs. 2 and 3, Plate 1.)
3. *c.* Hoisting crab and steam engine.
4. *d.* Drill or chisel and fall apparatus. (Plate 2.)
5. *e.* Sludge pump or mud cistern. (Plate 3.)
6. *f.* Boring rods and tools.

The Tubbing Apparatus comprises :—

7. *g.* Cast-iron tubbing with moss or stuffing box, temporary bottom, bolts, and weezes or sheeting. (Plate 4.)
8. *h.* Lowering apparatus.
9. *i.* Apparatus for filling space behind tubbing with mortar.

A brief description of these parts will be necessary.

1. *Pulley Frame and Shed.*—This consists of a strong eight-legged frame of fir wood, with oak sills and pulley-balks. The pulley, 6ft. 6in. diameter, is made of cast-iron, and is very strong. It is chain grooved, and the chain of the hoisting crab passes over it. About 38ft. above ground two strong sleepers, bolted on the inner legs of the frame at right

angles to the direction of the boring beam, carry rails on which a waggon with 18in. diameter wheels runs. This waggon may be easily moved in either direction by means of two small crabs (or winches). The drill is drawn from over the pit when not in use, on this wagon. The pivot chair of the boring beam is fixed on a strong oak sleeper about 14ft. 6in. from the surface. This sleeper is also supported by a strong trestle. At 25ft. from the surface a light platform is fixed on one side of the frame, to enable a man to take hold of the boring rods when being screwed on to or off the boring gear. These rods rest against the side of the frame when not in use. The pit mouth is covered by two strong scaffolds running on iron rails. When over the pit only a round hole, 7in. diameter, to allow the boring rods to pass through, remains. This hole, of course, is in the centre of the pit. The scaffolds are kept in position by snatch-hooks. In case it is necessary to uncover the pit, two trap doors, lying on either side of the twin scaffolds, require raising, and the snatch-hooks being lifted the scaffolds may be rolled aside at right angles to the boring beam, and then secured. The top of the scaffolds is perfectly level with the floor of the boring shed and the ground surface. Rails fastened on the scaffolds, when the pit mouth is closed, correspond with a line of railroad laid to where the mud cistern is to be emptied. This cistern is brought on a strong truck just over the pit mouth. The shed is a slight construction of fir timber and deals, enclosing the engine and crabs.

2. *Boring Beam and Moving Gear.*—The beam consists of a strong oak balk, strengthened with iron plates and stretchers. (Fig. 2, Plate 1.) At about one third of its length it rests on an iron axle, moving in a double pivot chair, to enable the beam to be moved aside, and uncover the pit mouth when needed. The shorter length of the beam is towards the pit, and the

other towards the crabs and engine, being connected with moving gear by an iron connecting rod. A short rod and chain, attached to the extreme end of the longer lever, connects the beam to another strong balance beam of oak, moving on an axle fixed at its extreme end, and loaded with cast iron weights so as to balance part of the weight of the boring apparatus. The effect to be exercised by the moving gear (Fig. 3, Plate 1.) is by this means much lessened. At the end of the shorter lever of the boring beam, the swivel and the lengthening screw suspending the boring apparatus are hung by two strong chains exactly over the centre of the pit. The moving gear is simply a crab, consisting of two iron axles, connected by strong cog wheels, and revolving in pedestals fixed to oak sleepers. Outside the pedestal one of the axles carries a disc crank containing several holes, allowing the crank pin to be fixed at various distances from the centre, thus changing the length of stroke. In addition to the pinion wheel the other axle carries a fly wheel, and, outside the pedestal, a chain pulley to connect the moving gear with the steam engine by means of an endless chain.

3. *Hoisting Crab and Steam Engine.*—The crab is fitted upon oak sleepers, firmly bolted on brick foundation pillars, between which the balance lever moves up and down below the surface level. The drum of the crab is made of cast-iron, and it is fitted with a spiral chain groove. A strong cast-iron wheel is fixed on the axle, and is driven by a pinion carried on the engine shaft. This is not keyed fast, but is secured by gearing allowing the pinion and axle to be disconnected by means of a lever. (Fig. 4, Plate 1.) The engine shaft carries a chain pulley to drive the moving gear, as before mentioned. This pulley is also fitted with disconnecting gear. These arrangements allow the engine to drive either the hoisting crab or the moving gear. By means of a strong break any weight may be lowered without steam being

turned on. The engine is a single horizontal cylinder of 30 to 40 horse power, with light fly wheel and reversing gear. To gain power, the crab chain is doubled up over the pit, and an intermediate block pulley used. The chain links are 2½in. diameter.

4. *Drill, or Chisel, and Self-acting Fall Apparatus* (Freifall, Plate 2.) are entirely made of best wrought iron and cast steel.

The drill is made in three parts, viz.:— (Figs. 6, 7, 8, 9, and 10, Plate 1.)

The blade holder,

The drill holder or tree,

The blades.

The blade holder is made of very strong forged iron worked into the shape of a double Y. Its greatest length is about 6in. less than the contemplated diameter of the pit. The diameter of Rhine Elbe, No. 2 pit, was 14ft. 2in., and the greatest length of the blade holder was 13ft. 8in. The section of the blade holder is rectangular, and a groove is planed out in the lower side, into which the steel blades are fastened by means of side keys driven through holder and blades. Notches (five in number) forged on the upper side of the blade holder serve to secure it to the drill holder. The drill holder consists of five wrought iron branches, which merge into one at the top. The section of the lower branches is square, and the end of the single branch is turned in the lathe, and at the top of it a round steel knob is keyed in a hole bored for the purpose. A large rectangular hole is cut through the tree below the cylindrical part, and an iron plate about 13ft. long is secured therein, to guide the drill while working or being lowered. Ten cast steel cutters, carefully planed, sharpened, and tempered, are keyed on to the blade holder. They are rectangular in cross section, and the edges are triangular. The section of the cutters is not identical for all. The four outside blades scoop out the pit sides, and have an edge similar to an adze.

The next four outside blades are rectangular, while the two blades on the central branch of the bearer are slightly curved and arranged to cut about 8in. deeper than the rest, to provide a sump in the centre of the pit. The wear of the blades was but slight during the operations at No. 2 pit, and bluntness did not retard sinking. Each blade is secured by two sets of double keys. The edge of the blades, when fastened, forms the figure of a double Y. This form has been chosen for the following reasons.

If the general form of boring chisel (a straight line) had been adopted, the stone remaining in the pit bottom, between each stroke would have been triangular in form (Fig. 11, plate 1), and, with a very small angle between the radii of the strokes, the thickness would be much increased at the full length of the radius, and the bulk remaining between the grooves would take a considerable time to clear. This is the reason why MM. Kind & Chaudron, who use a drill with a straight edge, are obliged to bore first an inner pit of small diameter, and then widen it out with larger drills. If we sketch the grooves cut into the pit bottom by Lippmann & Co.'s drill, it will be seen (Fig. 12, plate 1) that the stone is cut into a number of small lozenges and triangles, thereby being reduced to the consistency of mud. Another reason for the choice of the double Y form is, that the blades, if placed in a single straight line, slip and slide when the strata is of unequal hardness, which would easily make the pit crooked. The chisel with edge of double Y form, has a broad basis, and being guided at the top of the drill, and falling freely at every stroke, without any connection between it and the bore rods continuing, must remain plumb. The free-fall apparatus is difficult to explain in detail. Some idea of the arrangement may be obtained from the following rough description. The top part of the drill slides in an iron cylinder, and a key through the top of it projects on each side, and works

in slits cut in the cylinder, thus preventing the drill from falling out of the cylinder. The bore rods are screwed on to the top of the cylinder. Two spring hooks inside the cylinder take hold of the steel knob on the top of the drill, and when the cylinder has slid to the bottom of the cylindrical portion of the drill, a heavy iron ring (termed the "dead weight") slides over the cylinder and opens the snap hooks (the lever ends of which project outside the cylinder), thus releasing the drill, which falls freely to the bottom. By means of a somewhat elaborate contrivance, the drill and the "dead weight" are raised, and the drill is released as before. The height of the fall of the drill can be regulated by means of the arrangement of the "dead weight." The drill falling freely does away with any transmission of the shock of impact to the boring rods, and the number of strokes per minute can be increased very materially, without risk of breakage. The drill used weighed 37,500 lbs., the steel blades 4000 lbs., and the self-acting fall apparatus 7800 lbs., being a total of about 22 tons. The cost was in 1874 £2400, at Paris.

5. *Sludge Pump or Cistern (Plate 3).*—This draws out the mud into which the stone has been converted by the drill. It is made of sheet iron, and the bottom is pierced with 27 holes of about 12in. diameter, with plate-iron valves fitted with rods and handles, allowing each valve to be raised separately in emptying the cistern, which is divided into three compartments, so that the whole contents would not be emptied by reason of the failure of one valve. Several bows are fixed on the top of the cistern, and an oak beam (6in. × 9in.) is bolted on, and these bear the screw-end of a boring rod. This can, of course, be connected with the boring rods, and thus the cistern may be lowered. The cistern may be emptied from the side by means of three slide valves placed on one side. When it reaches the pit

bottom it is alternately raised and lowered about half a yard for 15 minutes, being at the same time gradually turned round. The mud enters through the valves, and after a quarter of an hour's rest to allow it to settle, the cistern is raised and emptied. As a rule the cistern had to be twice lowered and filled before the drill could be put to work again.

6. *The Bore Rods* are made of 3¼in. square iron, and are each about 27ft. long. Short lengths allow gradual increase in the total length. A lengthening screw (Fig. 15, plate 1) which turns in a swivel, and is suspended to the boring beam by two chains, is attached to the rods. The screw can be lengthened about 1 yard. On reaching this limit a 3ft. rod is put on and the screw is regulated accordingly. By means of handles (Fig. 16, plate 1), which are fastened to the square part of the screw, the drill is turned at every stroke when being raised from the bottom. The other implements used only differ from tools ingeneral use by reason of their strength.

7. *The Tubbing Apparatus (Plate 4).*—Cast-iron tubbing, moss-box (Fig. 18, Plate 1), temporary bottom, &c. The tubbing consists of cylindrical rings 5ft. in height, cast in single pieces. Each ring hasa flange on top and at bottom. These flanges are turned on the lathe, and bolt-holes are bored in them so that the segments may be screwed together and rendered watertight by means of lead sheeting. A strengthening rib is cast inside each ring, about the middle of its vertical height. Before being used each ring is tested by water pressure, in a specially constructed chamber, to double the pressure which it is required to bear in use. The tubbing consists of 52 rings, the weight of which is 818,746lbs.; the two rings of the moss-box weigh 45,797lbs.; and the temporary bottom 14,565lbs.; or a total of 879,108lbs., or about 439⅓ tons, in which weight the bolts and sheeting are not included. If the tubbing was bolted together, the water could not pass through it

when being lowered, but would, of course, well up from under it and fill the pit. To prevent this the moss-box, which is a kind of stuffing-box, is screwed on the lower end of the tubbing. It consists of two pieces, the outer being a strong iron ring of the same diameter as the tubbing, having an inner flange at the top fitted to screw to the lowest ring of the tubbing, and a thick outer flange, without bolt-holes, at the bottom. The inner piece allows the outer to slide over it, and has at the bottom a strong outside flange, while at the top six cast-iron ears project inside the pit, and serve to hang the lower part to the tubbing by means of six long eye-bolts, which are suspended from iron plates held in position by the bolts which pass through the flanges of the segments of tubbing. When the pit was finished these plates, &c., were taken or cut away, leaving it its full inside diameter. The space behind the inner piece of the moss-box is tightly packed with clean, dry moss, kept in place by a strong net when the tubbing is being lowered. This net is fastened to the two flanges by means of screws, and is bound against the moss by strings. When the tubbing is being lowered the moss is not pressed, but when the lower portion of the box touches the pit bottom it stops, and the tubbing, continuing its descent, forces down the top piece of the moss box, which, sliding over the lower piece, presses the moss tightly against the lower flange and the pit sides, thus preventing the escape of water under the foot of the tubbing. As a matter of precaution the space behind is afterwards filled up with hydraulic mortar. When the pit is sunk a few yards below the moss-box, a double wedging crib is laid, packed, and wedged, and some courses of ordinary tubbing are put in and closed against the lower flange of the moss-box. Holes 2½in. diameter are cast in the top segments, so that this length may be filled at the back with hydraulic mortar. A temporary bottom is screwed against the middle

g or rib of the lowest course of tubbing, converting it
o a vessel which would float upon the water if a certain
antity was not allowed to run into it to give the necessary
ight for lowering. This does away with the difficulty
l danger of dealing with the great weight it would be if
; cushioned. This bottom is concave, and has a manhole
the centre, to be used if reqduire. The outer diameter is 1in.
s than the inside diameter of the tubbing flanges, allowing
to be drawn out of the pit when the tubbing is completed.
false flange of sheet iron about 1in. thick, (Fig. 17, Plate
consisting of three segments with overlap joints, is screwed
er the temporary bottom, increasing the diameter 6in. or
n. Lead sheeting between the flanges renders the connection
ater-tight. When the tubbing is ready for lowering, a
rong cover is put on the manhole. The tubbing bolts
e ordinary bolts of best quality. The sheeting lead is
out $\frac{1}{8}$in. thick. The pieces forming a whole joint are cut
antwise, and project about $\frac{1}{2}$in. beyond the flanges, being
ated with red lead immediately before being used. The
ints are carefully stemmed, back and front.

8. *Lowering Apparatus.*—The tubbing is lowered by means
six screws about 12ft. long, on which are brass nuts,
rrying on each bolt an angle wheel driven by an angle
inion, the axle of the latter being provided with a handle.
ix men placed at these handles, and turning them exactly
gether, lower the tubbing at the command of the master
orer. The tubbing is hung on the screws by bore rods of
in. square iron, each 10ft. long. Each ring of tubbing
rolled over the pit's month on strong cross timbers,
oisted by the steam crab, and lowered on to the top of the
ubbing already put in. Three of the suspending rods are
nscrewed, while the remaining three steady the lower
ubbing, which is floating in the water. The new ring is
hen screwed to the rest of the tubbing, the lead sheeting

stemmed, and the three unconnected rods refastened to the lowering screws. The column of tubbing is then lowered 5ft. (the height of the ring), a certain quantity of water being allowed to run inside the tubbing for that purpose. This process is repeated till the moss-box touches the bottom, and the moss is compressed, as before mentioned.

9. *Filling the Space behind the Tubbing with Hydraulic Mortar.*—The mortar is mixed in the following proportions:

11	bushels	hydraulic lime.
11	,,	sharp river sand.
11	,,	Rhenish pozzuolana or trass.
4	barrels	Portland cement.

The lime is finely powdered and riddled, mixed dry with the sand and trass, cement added, and the mixture thrown into a hand mortar mill, the requisite quantity of water being added. Two of these mills are placed close to the pit on opposite sides, and the mortar runs directly out of the pans into sheet-iron pipes 4in. diameter, which lead it to the pit bottom. The mortar must be kept running, or it will separate into its constituent parts. After some practice the men managed this very well, and were able to fill up about 50ft. in eight hours, using a single mortar mill. The pipes are drawn up and shortened as the space is filled. MM. Kind-Chaudron use stiff mortar, forcing it down sheet-iron boxes with sliding pistons. MM. Lippmann's process is more rapid, and fills up all crevices more completely; it also prevents the water exercising direct pressure on the tubbing after the mortar has set. Possibly the tubbing used might safely have been lighter than it was.

Having described the apparatus and implements used for boring and tubbing the pit, the writer briefly relates in what manner the work was carried on.

In 1857, No. 2 Rhine Elbe pit had been sunk 16 yards in the grey marl, the diameter being 10ft. It was then

topped on account of the quantity of water met with. The it was walled, and buntons, ladders, and brattice put in. as in 1874 it was determined to make No. 2 a winding pit s well as a principal air shaft, it was resolved to increase he diameter to 12ft. inside the tubbing flanges: consequently it was necessary to bore it 14ft. diameter. In order o give room to move round the tubbing, the top portion equired to be of still greater diameter. The brickwork as therefore pulled out, and a chamber, 10ft. deep and 2ft. diameter, sunk from the bank, the pit being widened o 14ft. diameter for 12 yds., this being the limit to which the ater could be kept under by a donkey engine and 12in. ifting set. The widening of the pit and the destruction of ll timber below that depth was accomplished by the borer. This work was very difficult, as the pit was free in the entre, and the blades only worked at the circumference on the cemented brickwork, oak cribs, buntons, and iron pipes walled in the sides. The work, however, proceeded regularly, and it was hardly possible to recognise the small fragments of iron and wood in the mud cistern. The pit being cleared down to the depth sunk (16 yds.) the remaining 80yds. were proceeded with as follows:—

The pit was bored 14ft. diameter down to 96 yards, the tubbing lowered, the space behind filled with mortar, the water drawn out, the lowering rods, &c., taken out and the temporary bottom removed. The pit was sunk about 10 yards by manual labour, and the closing tubbing put in. The further sinking then proceeded in the usual way.

The drill or borer, with the fall apparatus, was lowered into the pit after the platforms had been pushed aside; the fall apparatus was regulated to act for a given drop (from 18in. to 30in.). The platforms were pushed together again, and the drill suspended thereon by means of a key. The rods

were then screwed on to the fall apparatus, and rods added as the borer was lowered till it reached the bottom of the pit. The boring beam set at the low stroke was connected to the rods and set slowly in motion, gaining speed as the drill set to work regularly. The drill, set loose by the fall apparatus, fell on an average more than 24in., its weight, including the blades, being 41,500lbs., as before stated. The number of strokes was from six to eight per minute. While the drill was raised it was turned round by eight to twelve men at the lever ends every two or three strokes. The head or master borer lowered it by means of the lengthening screw when needful. When the mud in the pit bottom impeded the turning of the drill, it was brought out of the pit, and the mud cistern lowered and filled (twice as a rule) till the bottom was cleared.

The drill was then lowered again, and so forth. When the pit reached a depth of ninety-six yards, a borehole 10ft. deep and 5ft. diameter was put down in the centre, to collect all debris which might be on the pit bottom, or might fall thereon. The pit bottom and sides were then planed as smooth as possible by means of the drill, which was lowered without the fall apparatus, and worked rapidly up and down with a very short stroke, thus only touching the bottom and remaining constantly suspended to the beam. The pit and borehole were then cleared a last time and the lowering of the tubbing began. The beam and platforms were removed and the lowering screws 12ft. long were set on scaffolding in the pulley frames. The two cylinders of the moss box were then rolled on strong sleepers placed across the pit, the interior portion being set to the centre of the pit. The upper part was then slid over the pit and rested on props so that the distance between the two flanges was 5ft. (Fig. 18, Plate I.) Narrow fir deals were screwed at the back of the flanges, and the well-dried moss packed closely and rammed with wooden hammers

in the space thus left. The props were taken out as the workmen packed the moss up to them. The packing being finished, the deals were taken off and the net substituted. The lower part of the moss box was suspended from the upper, on which was laid the first tubbing ring. In addition to the top and bottom flanges, this ring had two intermediate ones, turned on the lathe and pierced with bolt-holes. The temporary bottom was screwed under the lower of these intermediate flanges, while a sheet iron ring in two halves pierced with six large holes was screwed under the upper one. This ring projected inside the tubbing, and the rods suspending the tubbing while being lowered passed through the holes and were keyed underneath. These rods being connected to the lowering screws, the tubbing was lowered on to the water; three rods were then disconnected. Another tubbing ring was set on the first and screwed fast. The tubbing was then lowered 5ft. Another ring was then put on in like fashion, screwed, the sheeting stemmed and lowered, and so forth till the moss box reached the bottom. The suspension rods were then unscrewed, and the inside of the tubbing filled with water. By the great weight of the tubbing the moss was pressed downwards and against the pit sides. The space behind the tubbing was then filled with hydraulic mortar. When the water was drawn the tubbing was found perfectly tight, both at the joints and the foundation.

The boring through the brickwork at 12 yards depth was started on the 16th of May, 1874, and the boring operations were ended down to 96 yards on the 27th of April, 1875. The needful preparations for lowering the tubbing were then made, and the operations were finished and the space behind filled up by the 22nd of June, 1875. The water was drawn and the pit cleared of the working apparatus by the 30th of June, 1875.

Very few accidents happened during the boring, the following being the list:—

July 12-13, 1874.—Breakage of a rod screw while the mud cistern was at the bottom. The latter was fished for and caught in a few hours' time.

July 26-28, 1874.—The boring beam being too weak was repaired and strengthened with iron plates.

November 11-26, 1874.—The self-acting fall apparatus sent to the factory to be repaired.

January 14-23, 1875.—Breakage of a rod screw. The drill remained at the bottom. A special hook had to be sent for to Paris. The drill was caught and drawn out in two hours' time.

A considerable loss of time ensued at the commencement of operations, as the steam engine required replacing by a more powerful one.

The cost of Sinking and Tubbing down to the depth of 96 yards was as follows:—

	Wages, Salaries, &c.			Materials.			Total.		
	£	s.	d.	£	s.	d.	£	s.	d.
Pulley Frame and Shed..	..	..	..	1030	7	2	1030	7	2
Implements and Tools for Boring and Tubbing	..	..	..	6888	10	4	6888	10	4
Steam Engines and Pipes..	..	..	..	946	4	0	946	4	0
Boring Expenses.....	2227	15	6	881	18	0	3109	13	6
Tubbing.....	258	3	6	4918	16	10	5177	0	4
Filling up with Mortar..	101	17	4	419	10	10	521	8	2
Officers' Salaries, Travelling Expenses and Contractors' Premium....	2349	7	9	..	..	..	2349	7	9
Total.....	£4937	4	1	£15,085	7	2	£20,022	11	3

The cast-iron tubbing alone cost £4770 16s. 8d. It would be considerably less expensive at the present time.

The machinery and apparatus were in good order after the completion of the work.

The No. 2 Rhine Elbe pit being sunk on the premises of 1 pit, no boilers or shops for smiths and carpenters were ded, but the costs for smiths' and joiners' work are fully luded in the item for salaries given in the above table.

Mr. GRIMSHAW said: At the outset we were told that the t of the No. 1 Rhine Elbe pit, which was sunk to a depth 113 yards through the grey marl, was upwards of 00,000; that gives about £985 per yard sunk. That pit s sunk by manual labour. Whereas the cost of the No. 2 , sunk under similar conditions, was about £210 per yard. ese figures show an astounding difference in favour of ssrs. Lippmann's process. The difference in cost may, in reat measure, be accounted for by doing away with the essity of pumping 9,000 gallons of water per minute. course, in an ordinary wet pit, the pit bottom has to be pt clear for the sinkers to work, for which purpose heavy kle is needed, and very often that tackle is of no use after pit has been sunk and the water is tubbed off. It tainly seems a very great step in advance to be able to k a pit 14ft. in diameter in one operation, and, in addin to that, to effectually tubb off the water.

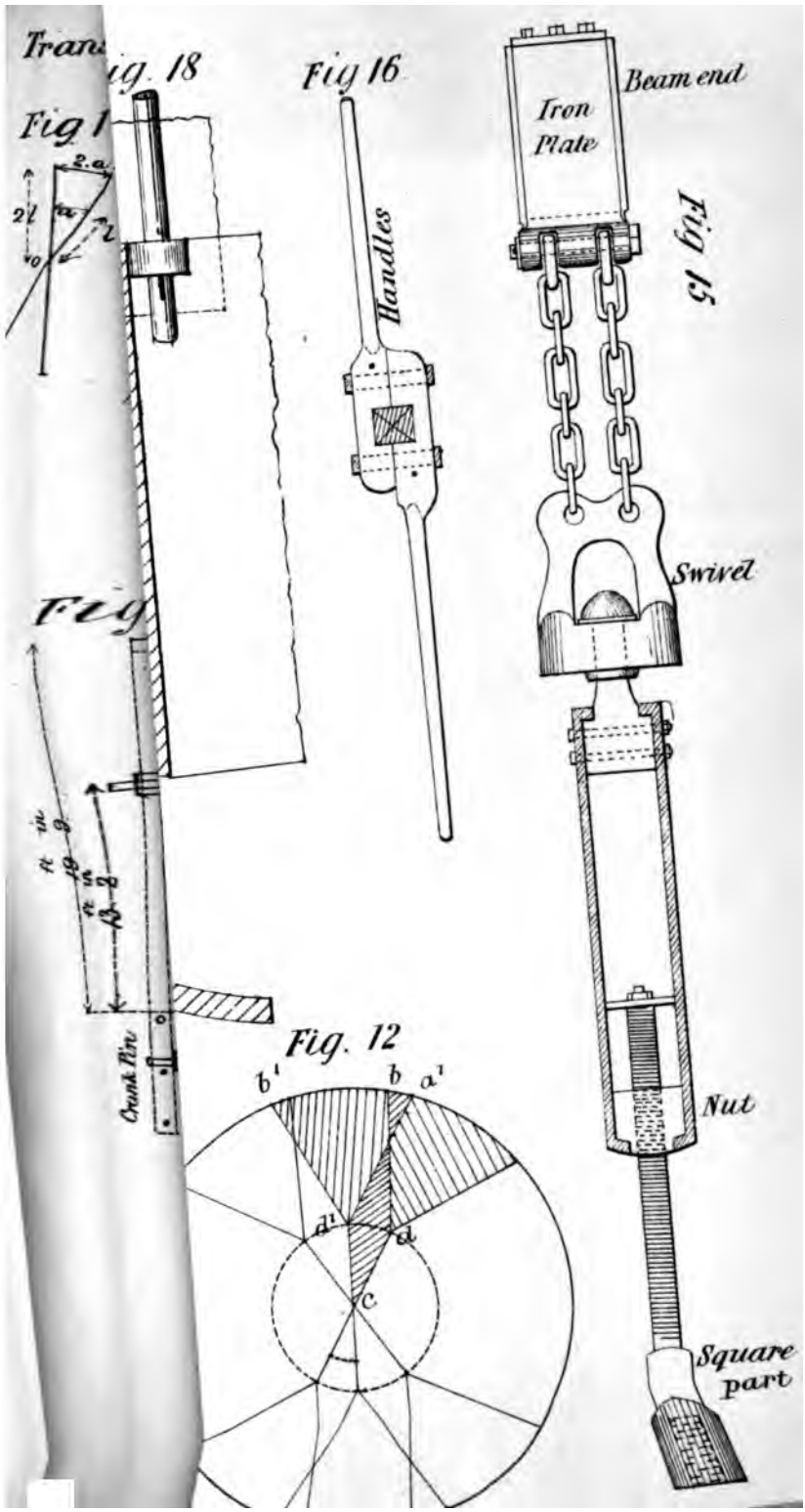
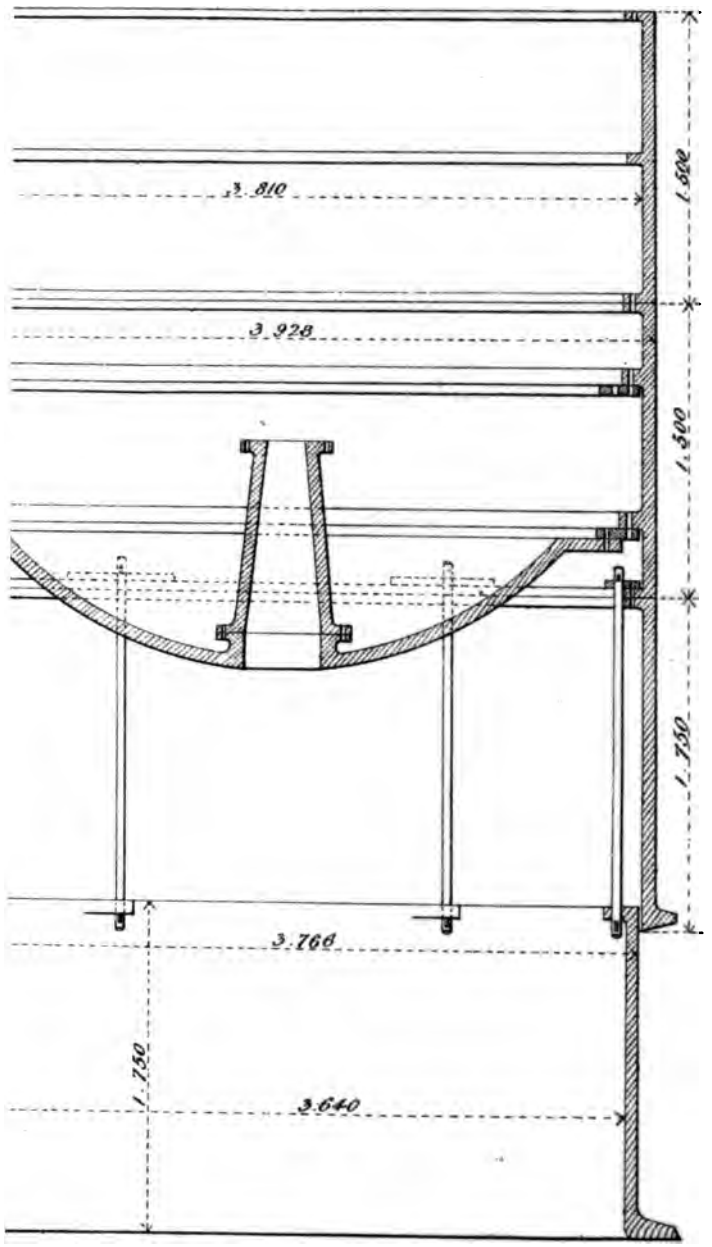
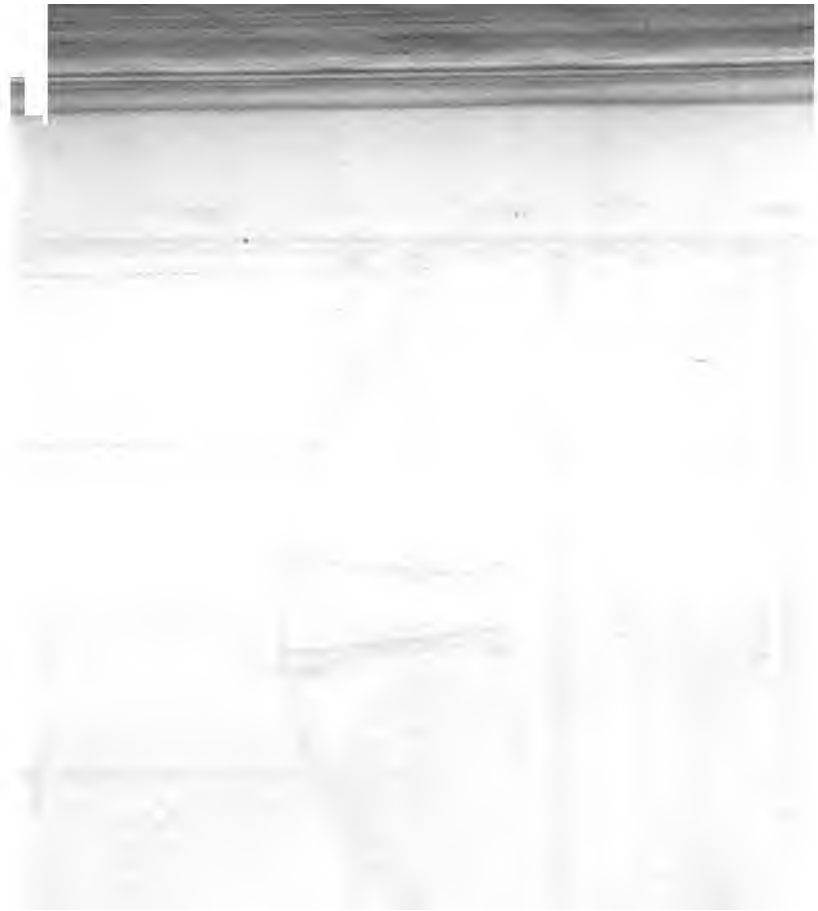


Fig 16
Handles
Fig 15
Beam end
Iron Plate
Swivel
Nut
Square part
Crank Pin
Fig. 12
b'
b
a'
d'
d
c

Man. Geo. Soc. Part XVIII. Vol. XIV. Plate

Scale 1/40th





TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIX. VOL. XIV. SESSION 1877-8.

At the ORDINARY MONTHLY MEETING of the Members of the Society, held on Tuesday, the 26th March, 1878, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., President, in the Chair.

Mr. Richard Smith, Hollinwood, was elected an Ordinary Member of the Society.

THE SPONTANEOUS COMBUSTION OF COAL.

The PRESIDENT drew attention to the importance of this question considered from a mining or an export point of view. At an inquiry recently held in Liverpool with reference to a coal-laden ship having taken fire at sea, his evidence was desired as to the character of certain coal which had been sent from Lancashire. The coal in question —from the Rams or Six-foot Mine—was remarkably clean, and free from the elements of spontaneous combustion; but other coal, in part from Rainford and in part from the Whiston portion of the district, had been loaded with it. The Assistant-Inspector of Mines for West Lancashire stated that two of the mines from which this coal had been

derived were then on fire from spontaneous combustion; and he, perhaps, if correctly reported, went a little too far in saying that those seams were not suitable for export. It was quite possible that in a seam of coal there might be bands of earthy matter running through it which were liable to spontaneous combustion, and that the coal itself might be free from it. It seemed to him, therefore, a very serious matter to denounce one or two seams simply because there might be intervening bands that were liable to spontaneous combustion. Whilst waiting to be examined he was very much struck with the description given of the method of loading ships at Liverpool. It seemed that the stevedores—the persons who had charge of the loading of the vessels—disclaimed all responsibility for the way in which the cargo was put on board. An old stevedore who was examined said that whatever cargo came he put it in. He (the stevedore) held the captain responsible for seeing that his ship was properly loaded. When he (the President) was examined, he pointed out that if people who were accustomed to stack coal in Lancashire were to stack it after the manner in which it was put on board ship—that was, by dropping it from the deck into the bottom of the hold—they would not be surprised at spontaneous combustion arising from the consolidation that took place owing to that treatment. The usual way is to begin by building it up quietly from the bottom, or placing a few planks for the coal to slide down. That precaution seemed never to be observed in the loading of ships. This subject has already been treated of in one of the mining institutes; but he thought the subject was still far from exahusted, and felt sure some of the members could give the Society a very interesting and useful paper on it.

Mr. De Rance said that from the reports in the London papers it appeared that by some persons it was considered

Lancashire.coal *per se* as much more liable to spontaneous combustion than coal from other districts; and that, if it had been misunderstood, he thought some official correction of the reports would be desirable.

Mr. CHADWICK agreed with the President's view, and to the intervening bands being the source of spontaneous combustion rather than the coal itself. Such bands exist above the Trencherbone and Ravenhead Main Delf Mines, from which latter the coal in question is said to have been derived.

Professor DAWKINS said that he thought the effect of iron pyrites was one which would prove of interest in connection with this question. Three years ago, when in New South Wales, he had occasion to visit a very thick seam of coal near Mittagong. There was 12½ft. of coal, a thin bed of shale, and then another 12½ft. of coal, making in all 25ft. One of these seams had been on fire at the outcrop for a considerable time before he got there, and it was solely due to the decomposition of iron pyrites, which was present in considerable quantity at that spot, and which, on becoming wet, generated sufficient heat to cause combustion. He was not able to speak as to whether this might or might not be the source of spontaneous combustion in English mines, but in some of these there certainly was a good deal of iron pyrites.

Mr. WILD said that on the top of the Ravenhead Main Delf coal there is a large amount of iron pyrites. He had had experience of heating in this mine which subsequently resulted in combustion and the cessation of work there.

THE MINES OF THE PARYS MOUNTAIN, ANGLESEY.

Discussion upon the paper read by Mr. Evans, at the last Ordinary Meeting of the Society, was resumed.

The Honorary Secretary read the following communication from G. H. KINAHAN, M.R.I.A., of the Irish Geological Survey :—

Mr. Evans's description of the "country" and minerals of Parys Mountains reminds one very much of those at the Ovoca Mines, Wicklow, Ireland. At Ovoca, but especially to the east of the river in East Cronebane and Connary, there are many felspathic and felsitic rocks; some of the latter (petro-silex) being so silicious as to be scarcely distinguishable from quartz-rock and quartzite. In this part of Wicklow the surface of the country (over these rocks) has the same "burnt" appearance as that mentioned by Mr. Evans, while the copper ("yellow ore") in the mineral channel is of low percentage (3·5 to 8), but it is associated with considerable deposits of "sulphur ore" (pyrite and marcasite). There is also in Kilmacoo, part of the Connary set, a mineral very similar to the Parys Mountain—"bluestone"—it locally goes by the names of "bluestone," "silver-blende," and "kilmacoite." At Connary, however, it is worked by a London Company, who have patented a process for reducing it, and at present are actively employed in raising and shipping the ore. The analysis shows that it is a somewhat similarly constituted mineral to the "bluestone" of Parys Mountain.

The various writers on the Ovoca Mines seem to consider the felspathic and felsitic rocks to be eruptive-bedded felstones: except Weaver, who states that some of them are hornstones. Weaver appears to be correct; for while some of these felstones are eruptive-rocks, many of the rest are evidently metamorphosed shales and tuffs. These "paroptesis" or locally metamorphosed rocks, in many characters are similar to normal felstones; but they are always cleaved or laminated, or show the lines of cleavage or lamination, while if carefully worked out, they can be traced from hornstone into either unaltered shales, slates, or tuffs.

I would suggest that Mr. Evans goes to extremes when he wishes to include all the felspathic and other eruptive-rocks among those of sedimentary origin. In different places in the tracts of Cambro-silurian rocks, to which he has alluded in his paper, there are rocks undoubtedly eruptive; although in different places in the same areas there are other rocks, now mapped as eruptive, that properly ought to be described as paroptesis or baked sedimentary rocks, or rocks that have been metamorphosed in the the vicinity of a local source of igneous or perhaps slightly aqueo-igneous vent. This is very evident in the Cambro-silurians of Wicklow, Wexford, and Waterford, as interstratified with them are great sheets of *eruptive* felstones, eurytes (basic felstones), whinstones (probably gabbros), agglomerates, and other tuffs; but, at the same time there are great tracts of metamorphosed shales, slates, and tuffs in places scarcely distinguishable from felstones, eurytes, and gabbros. These Paroptesis rocks always occur adjoining the vents of eruption in the rocks below those in which the bedded normal eruptive rocks are found, and usually are associated with one or more protrusions of basic elvan and rarely with silicious elvans. The basic and silicious elvans being the roots of the eruption rocks; that in higher beds form sheets in the Cambro-silurians. To this subject I have previously referred, in a communication laid before this Society, "On the Rocks of the Ballymoney Series, Co. Wexford,"* in which it was pointed out that the interbedded eruptive rocks occurred solely in the upper Cambro-silurians. The changes in the sedimentary rocks of Wicklow, Wexford, and Waterford due to paroptetic action are,—certain argillaceous rocks are altered into hornstones, some of the latter being so silicious that they might be called quartzyte—felspathic tuffs into rocks scarcely distinguishable, except petrologically from felstones—and basic shales and tuffs into rocks

* Trans. Manc. Geo. Soc. Vol. xiv. p. 145.

undistinguishable, except petrologically, from eurytes and gabbros. The changes of sedimentary rocks into rocks having characters similar to eruptive rocks is also conspicuous in places in the Counties of Kerry (Upper-silurians —Dingle beds), Clare (Cambro-silurians), Galway (Cambrians and Cambro-silurians), Mayo (Silurians), and elsewhere; while associated with these Paroptesis rocks are others evidently eruptive. But in places it is impossible to draw a boundary between the normal eruptive and the normal paroptesis rocks—examples are—at the vent of eruption on the west side of Beginish, Valencia Harbour, County Kerry; in the Silurians of the Culfin Valley, at the north-west extremity of Galway; also in numerous places in Wicklow, Wexford, and Waterford and elsewhere.

An observer, studying one of these masses of rock, partly eruptive and partly paroptesis, will come to different conclusions in accordance with the portion with which he is most familiar. If he pays particular attention to the sedimentary rocks that have been subjected to paroptetic action, he may be led to believe that all the rocks are of sedimentary origin; while if, on the other hand, his study has been principally directed to the eruptive portion, he may come to an equally erroneous opinion, and put all among the eruptive rocks. It would appear to me that Mr. Evans has gone into one of these extremes, and having found rocks in various places, classes as eruptive, although evidently originally sedimentary, he has too hastily come to the conclusion that all eruptive rocks are of sedimentary origin.

Mr. Evans' paper on Parys Mountain is especially interesting to those acquainted with the rocks of South-East Ireland, and it would almost induce one to enlarge on the subject. This, however, would, in part, be outside the question raised, besides that at present I am not sufficiently acquainted with the rocks of South-East Ireland to give an unbiassed opinion.

Professor DAWKINS said he could say very little upon this subject, except that he shared Mr. Kinahan's views as to the soundness of many of Mr. Evans's conclusions. It seemed, however, to him, in the present state of our geological knowledge, really too much to ask them to blot out the terms "volcanic," "irruptive," or "igneous," from the Cambro-silurian rocks of Wales. He was sure no one could compare the crystalline rocks in question with the products of existing volcanos without coming to the conclusion that they were absolutely identical in structure. So far, then, he entirely disagreed with the conclusion of Mr. Evans. He certainly thought there was as good evidences of ancient volcanos, or of volcanic action, and igneous action generally, in Wales as are to be found in any part of the world; but with regard to the question, as to many so-called igneous rocks not being really igneous, that was a point which he thought Mr. Evans had a good deal to say on on his side. Many of the formerly called igneous rocks of the Principality might ultimately turn out to be metamorphic. It was a very interesting question which was raised, and one that would take much time and trouble; and even when they had expended all their time and trouble, in the present condition of chemical knowledge, he was afraid they would still be unable to arrive at any definite and precise conclusion, as to the action of segregation and the results of metamorphic action as distinct from those which were purely igneous.

Mr. DE RANCE said the author of the paper, from the fact of his living upon the ground, appeared to have accumulated a vast amount of facts which would be of use for future time; but as regarded Mr. Evans's conclusions, he (Mr. De Rance) should be inclined, with his colleague, Mr. Kinahan, and with Professor Dawkins, somewhat to demur.

That the terms used now for so long a time should be abolished—and not so much the terms as the ideas represented by them—seemed to him, in these 19th century days, an impossibility. He compared the specimens from Parys Mountain, exhibited by Mr. Evans, containing fragments of petro-silex, or hornstone, with some of the rocks in the lake district, where, in Cumberland, there was a vast series of volcanic ash (which undoubtedly had been projected from a volcano), intercalated with beds of trap; and when he found, by following the ash beds across a piece of country, that certain alterations had been induced by the metamorphic action produced by the heated lava flows, dykes projected through them, and found what was an ordinary ash on one side of a valley became petro-silex, or hornstone on the other; then he thought they had, in a district like that, clear proof—first, of a deposit of volcanic ashes, then of lava flows and dykes coming up from beneath. But an examination of the district revealed something more: they found mineral veins, and those veins traversed dykes, traversed volcanic ashes, and traversed the altered ashes which had been termed hornstone; and he took it they were altered altogether from the particular circumstances which produced the metamorphism of the rocks of that district. When he examined some of Mr. Evans's specimens, and saw their similarity to the lead-bearing strata of Patterdale and the copper beds of Coniston, he could not doubt that the same sequence of events had happened in Anglesey—first they had certain ashes deposited, afterwards there was an alteration of those ashes, and at a later period there were veins traversing them which got filled with certain materials. Whether those materials came from below it was impossible, without examination, to say definitely. In the locality which he had more particularly examined with regard to mineral veins—Alston Moor and the limestone district of Yorkshire—there was no doubt that minerals (lead and copper) had been

brought into faults—or into fissures worn by the action of carbonic acid gas in water—by the running action of water, and left there till the fissure became filled with various materials, the mineral portion being in the centre. He had the good fortune the other day to examine a large collection of rock veins brought to this country by Mr. J. A. Phillips, who had a large knowledge of mineral veins; and he could not but realise the fact that mineral veins had not one origin merely, but many; and though some—as those at Alston Moor—might have been derived from segregation, others doubtless had been derived from beneath, and had a source from below upwards, in the same sort of way as dykes; and it was possible that those of Anglesey might have been formed in that way. But there were, no doubt, different chapters of the story there, belonging to different periods of geological time.

Mr. Aitken said he agreed with the general tenor of the remarks made by the previous speakers, as well as by Mr. Kinahan in his communication; but it appeared to him that there had been some misapprehension with regard to Mr. Evans's intention. Mr. Evans was of opinion that the whole of these beds had been formed by deposition at the bottom of a Silurian Sea. At one time, and that, by some law of segregation not distinctly set forth, those beds arranged themselves in the laminated series which they eventually assumed. It did not appear that metamorphism was intended, as that term did not occur in the paper. They had, then, not only the statement made that there were no igneous rocks there, but that the beds in question had been formed by some strange law of nature with which they were not acquainted, and of which Mr. Evans, perhaps from the time placed at his disposal being too short, did not fully explain. He (Mr. Aitken) thought the discussion was taking a direction different from what was intended by the author of the paper. Mr. Evans, in the

concluding paragraph of the paper, said: "If this theory be correct, these great rock masses should no longer be termed igneous, and ought, instead, to be designated huge segregated strata." Without further information upon the subject they were certainly not in a position to accept Mr. Evans's theory. He (Mr. Aitken), for one, from all that he had read and seen, had formed very different conclusions. It was quite possible that in many places beds had been described as of igneous origin which ought more correctly to be called metamorphosed beds; but to say that they were altogether to erase the term "igneous" from the geological vocabulary, and further adopt the theory that there were no beds of igneous origin occurring in the silurian districts, was, he thought, asking them to accept too much.

Professor DAWKINS said that Mr. Evans's paper concluded with these words: "I hope that the remarks I have made will be the means of drawing to the subject the attention of more skilful geologists than myself; and thus, as I confidently expect, hasten the day when the terms igneous, volcanic, and intrusive shall cease to be applied to a single rock-mass in the Silurian and Cambrian formations in Wales." That was the point to which he (Professor Dawkins) had addressed his remarks.

The PRESIDENT said that Mr. Kinahan appeared to confirm to some extent the views taken by Mr. Evans. In the mines of Ovoca, which he (the President) knew from having visited them as inspector, occasionally the veins ran with the stratification of the country; so did they in the mines of the County Cork. The veins were simply like a bed in the rude stratification; but the ore was not deposited until the great cross course, or flucan of clay, interposed to cut off the communication. He thought it was on this point that Mr. Evans wished to introduce fresh views, and he (the President) was disposed, to a certain extent, to agree with him.

ON THE PALÆOZOIC AND SECONDARY ROCKS OF ENGLAND, AS A SOURCE OF WATER-SUPPLY, FOR TOWNS AND DISTRICTS.

By Charles E. De Rance, Assoc: Inst: C.E., F.G.S.,
Of the Geological Survey of England and Wales.

The rainfall of England, according to Mr. Symon's map, accompanying the Sixth Report of the River Pollution Commission, exceeds 25 inches per annum throughout the entire area lying west of a line, ranging from Shields to Reading, while west of a line trending from Shields to Start Point, the rainfall around the Lower Palæozoic rocks, forming the elevated tracts of the Lake Districts of Wales and Dartmoor, amounts to more than 75 inches per annum. With so large an area, receiving so abundant a rainfall, the existing urgent necessity of affording a more efficient water-supply, not only to our larger cities but to our rural population, becomes a matter of surprise, and an inquiry into the causes, which so often leave the inhabitants of this country, like Coleridge's "Ancient Mariner," "with water, water everywhere, but not a drop to drink," a subject of considerable importance.

Fifteen millions of the British population live in towns and cities, and supposing these to be all supplied with waterworks—12 millions of rural population are left—deriving their water-supply from shallow wells and flowing streams, almost always horribly polluted.

Through increase of population, and manufacturing requirements, the quantity of water annually consumed in England is steadily increasing, while the number of available sources of supply, being necessarily limited, the competition for the possession of suitable water-bearing areas,

especially those adjoining the more densely crowded centres, becomes keener and keener, and the Parliamentary and other preliminary expenses larger and larger.

Rival townships, after severe competition, obtain the whole of the water rights of a district to the exclusion of those who, from apathy, ignorance, or want of funds, neglected to claim a portion of the natural watershed due to them.

The Local Government Board and Parliamentary enquiries, at the best, only endeavour to ascertain whether any proposed water scheme laid before them is likely to fulfil the purpose desired for that particular, and have no machinery to see whether it is the best scheme, or whether it will interfere with the interests of other districts, who, through ignorance, are not represented.

In regard to their general fitness for drinking and cooking, the Rivers Pollution Commissioners classify waters in the order of their excellence, in respect to wholesomeness and palatability, as follows:—

Wholesome	1. Spring Water,	Very Palatable.
	2. Deep well water,	
	3. Upland surface water,	Moderately Palatable.
Suspicious	4. Stored rain water,	
	5. Surface-water from cultivated land,	
Dangerous	6. River water which sewage gets access to,	Palatable.
	7. Shallow well water,	

The value of spring and deep well waters is not merely due to their greater intrinsic chemical purity and palatability, but to their being peculiarly suited for domestic supply from their almost invariable clearness, transparency, and brilliancy, and their uniformity of temperature throughout the year, rendering them cool and refreshing in summer, and preventing their readily freezing in winter; and their utilization and conservation appears to be a matter not only worthy of enquiry into by the Society, but one of national importance, and to demand Imperial legislature.

The analysis of samples of rain from various parts of the country, made for the Rivers' Pollution Commission, prove that it is water that has washed a dirty atmosphere, full of products of respiration of animal life, animal and vegetable waste and decay, and fumes of manufacturing processes, which, carried by the winds, hang suspended until condensation of moisture takes place, and are entangled in the minute globules of water forming clouds.

Half-a-pint of rain water often condenses, out of 3373 cubic ft. of air, the quantity of air a man would breathe in eight days, so that in drinking that quantity he swallows an amount of impurity that would only reach his lungs from the air in eight days.

The lakes of Cumberland and Westmoreland all lie in true rock basins, excavated beneath the ordinary valley gradient by glacier action. Thirlmere is one of these natural basins, but the barrier which formerly enclosed the lake has been partially cut through, so that the original level of the lake is lessened. The proposed projects for utilizing the lake for Manchester water supply involve the restoring of this barrier by an artificial embankment, so as to raise the water level, and give a greater storage capacity.

The available rainfall is calculated on the average fall of a district over a long period of years, but the amount varies during the dry years of that period, as stated by Mr. Bateman in his evidence before the Royal Commission of Water Supply, "according to the declivity and geological character of the country, and its cultivation, and the amount of vegetation—the quantity which is taken up by vegetation, or is evaporated or lost in rivers, varying from about 9 inches to 16 inches, the smallest quantity being of course that where the rocks are hardest, and the declivities are the greatest, so that the water comes down in floods."

In the Loch Katrine district, and in the Welsh hills around the sources of the Severn, with an actual average rainfall of 75 inches, he takes 60 inches as the available average, of which not less than 12 would be lost by evaporation, &c., being a mean between 9 inches and 16, leaving a net available produce of 48 inches.

In impermeable districts consisting of the older rocks Palæozoic, rising to great elevations, the dry weather flow of the streams, due to springs only, amounts, according to Bateman, to one-fourth of a cubic foot to three-fourths of a foot per second from each 1,000 acres of area drained, giving an average of half a foot per second for a dry season, while the volume carried down by floods, ranges from 200 to 500 cubic feet per second, or 500 to 1000 times the dry flow. Reservoirs impounding these floods are able to increase the useful volume of the stream by returning one-third to one-fourth of them as compensation.

The amount of rainfall in a mountain district steadily increases in direct proportion with the elevation up to a height of 2000 feet, which falls chiefly on the side nearest the direction of the prevalent rain wind, thus the wet winds of the Lake District are the dry of Northumberland. When, however, the hills rising to 3000 feet are breached by valleys of lower elevations than 2000, the rain clouds are carried through, and their contents precipitated on the lee slope of the hills as at Wasdale Head and Beddgelert.

Similarly at Rivington the rainfall is 50 inches, while on the west slope of the hill it is 42, and at Belmont, in the Bolton Waterworks district eastward it is 53, while still further east, in the valley supplying Blackburn, it is only 42.

At Manchester, again, the rain is 38 inches, eastward at Denton reservoir, 300 feet above the sea, 34 inches, at Newton 65 inches, at the foot of the hill 46⅓ inches.

	Inches.
Towards the head of the valley	57·64
On the east side, over the summit	58·50
At the Sheffield Waterworks	46·00
At Penistone.....	39·00
At Sheffield	25·00

Proving that equal areas of country of similar elevation do not receive equal amounts of rainfall.

As heavy rainfalls often occur in the areas of small annual fall, as those of large amounts—four inches of rain have fallen in an hour in London.

In districts like the *Millstone Grits* and *Yoredale Beds* of the area drained by the existing Manchester Waterworks, though large quantities of water are absorbed by the porous sandstone, and the water supported by the beds of intervening impermeable shale, the rainfall received by the reservoirs, has been found to be no less than 33in. out of a total fall of 45¾in., the average of dry years. This small loss, due to absorption is due to the fact, that the springs discharging the percolated waters are all with the hydrographic basin.

Of the string of reservoirs supplying Manchester, extending over six miles of country, the upper one has an embankment 90ft. in depth, the second 100ft., the third 80ft., and the lower two 56ft., constructed of a puddle-wall in the centre, with slopes of clay overlaid by shale and stone; slopes 3 to 1 on the inside, and 2 to 1 on the out, and pitched inside.

One of the earliest embankments made in Lancashire—the Turton and Entwistle Reservoir—is 108ft. The service reservoirs of the Manchester Waterworks are 15ft. to 20ft. deep; at less than 15ft. depth it has been found that vegetation takes place upon the surface of uncovered water, the decomposition of the vegetation affording food for animalculæ and their consequent.

Permeable.		Impermeable.	
Upper Chalk.		Lower Chalk (generally).	
Upper Greensand,	50ft.		
Lower Greensand,	400ft.	Gault,	130ft.
Purbeck Beds, Portland Oolite & Sands,	60ft.	Weald Clay,	800ft.
Coral Rag and Calcareous Grit,	40ft.	Kimmeridge Clay,	300ft.
Cornbrash, Gr. Oolite,	200ft.	Oxford Clay,	400ft.
Inferior Oolite and Sands,	250ft.		
Keuper Sandstones.	400ft.	Fullers Earth,	40ft.
Upper Mottled Sands.	450ft.	Lias,	500ft.
Pebble Beds.	700ft.	Keuper Marls.	
Low. Mottled Sands.	500ft.		

It is hardly within the scope of this paper to consider the water bearing capabilities of the *Permian*, but numerous deep borings that have been made in different parts of the country, in search of coal, have afforded many facts of interest, in showing the extensive denudation of the carboniferous surface and still older rocks, that took place before its deposition, and also the occurrence of springs of good water lying in the Trias beneath the Lias and Oolites, as at Scarle, near Lincoln, which passed through the following sequences (classified by Professor Hull):—

	feet.
Alluvial or drift strata	10
Lower Lias (gypsum)	65
Rhatic beds	66
New Red Marl	573
Lower Keuper Sandstone	244
New Red Sandstone Bunter	542
Upper Permian beds	384
Lower Permian sands	16
Carboniferous (1900—2030)	130

The water occurred at a depth of 950ft., and rose 6 feet above the surface, and must have been derived from an outcrop twelve miles distant.

Amongst the borings, of which it is needless to give the details in the present paper, is one at Rampside, near Barrow-in-Furness, which reached a depth of no less than 2210ft. from the surface, in a fruitless search for coal. At a depth of 250ft. a spring of water was cut in the Permian Red Sandstone, which yields 13,500 gallons of water daily, flowing over at the top of a 1in. pipe, and rising to a height of 12ft. above the surface of the ground.

The rocks beneath the Permian have been proved by the boring to be of Yoredale age, the coal measures being absent, as stated would probably be the case by Mr. AVELINE and other geologists, before the boring was carried out.

An interesting feature in the boring is the presence of petroleum oils in the Yoredale Rocks, near the bottom, which caused the water, cut in penetrating the sandstone, to be much charged with oil.

The River Pollution Commissioners describe the *New Red Sandstone* Rock as the most effective filtering medium known, being at the same time a powerful destroyer of organic matter, every trace of organic matter, as at St. Helens and Tranmere, being converted into innocuous mineral compounds.

Occupying so vast an area—10,000 square miles—it will be only possible to point out a few instances of the great volume and purity of their waters.

At Liverpool not less than 6,000,000 gallons per day are pumped off an area of 10 square miles by the Corporation Wells, the well known as Green Lane Well yielding a daily average of no less than 2,533,050 gallons in 1875, and 2,903,712 gallons in 1876; the Dudlow Lane 1,103,307 gallons in 1875, and 1,169,494 gallons in 1876, from a bore hole 439ft.

deep; the Bootle Well 1,399,791 in 1875. This well is now being deepened, as an experiment to test the water bearing resources of the lower portion of the New Red Sandstone of that district; but it is much to be regretted that a site was not chosen east of Liverpool, where a large drainage area would have been available for the percolation of rain into underground springs.

A portion of the 20 square miles of area supplying the Liverpool private and Corporation wells is built over or covered with impermeable paving in the streets; and, further, only a portion of the eastern area is bare of drift boulder clay, which throws off the rain fall in surface floods, though a portion of the water is doubtless absorbed in passing through rock-cut valleys. The evaporation off this stiff clay land, exposed as it is to the influence of the sun and air, is doubtless at the least 12 inches per annum, and the percolation probably not more than 5in., though amounting probably to 10in. in the area bare of drift.

Assuming 1in. of rain to give 22,427 gallons per acre, or 14,353,280 gallons per square mile, which, spread over a year, gives a daily yield of about 40,000 gallons per square mile; the drainage area with 10in. of percolation would give a daily volume of 4 millions of gallons off 10 square miles, while the yield is $6\frac{1}{4}$ millions, proving the water in the subterranean supply is derived from an area outside the immediate surface drainage district, or else this water flows in from the river, along lines of faults, or that they act as direct ducts from other areas. That the water is abstracted from the surrounding Sandstones by the local lowering of the underground water-level there can be little doubt.

The presence of sulphate of lime in the water used in brewing at Burton-on-Trent, by Messrs. Bass, Allsopp, Salt, and other firms, is believed to give the Burton water its special pre-eminence in the manufacture of beer. Mr.

Molyneux believes the large amount of calcareous ingredients here met with (70 grains in an imperial gallon) to be due to the water dissolving all the gypsum of the Keuper Marls of Needwood Forest, from whence it flows down the dip planes of the strata to the Burton-valley fault, up which it rises, and is tapped by the artesian borings of the breweries.

"Herr Griess, F.R.S., informs Mr. Molyneux that the gypsum derived from the water used in brewing 1000 barrels of ale would be 250lbs.; so that assuming Burton produces annually 1,400,000 barrels of ale, no less than 360,000lbs of this mineral will be drank with the beer in various parts of the world. Of the water derived from the Burton Valley Gravels, and used in various operations of brewing, probably not less than 1,050,000lbs. of gypsum will be disposed of, which Mr. Molyneux considers will not represent one-tenth of the actual amount of gypsum being annually carried to the sea. And it is believed that many local subsidences which have taken place in various parts of Needwood Forest are due to the fracture and sinking of gypsum beds corroded by underground streams.

The water recently obtained by several of the large brewing firms from the Keuper Sandstone and Bunter beds rose 23ft. above the level of the valley, proving the great height of the sources of supply. These waters were softer than those from the Marls or from the Valley Gravels, the proportion of sulphate of lime being much less.

At Birmingham, with a population of 343,787 inhabitants, living within an area of 15 square miles, receiving a water supply of 7,500,000 gallons daily, three-fourths of the volume is yielded by wells in the New Red Sandstone of a depth of 130ft. to 400ft., affording water described by the Rivers Pollution Commissioners as "of a uniformly excellent quality," and the Perry Well "being one of the best waters for dietetic and domestic purposes they ever encountered." The yield is as follows:—

	Daily Yield. Galls.
Aston Well (120ft. deep, bore 400ft.)	3,500,000
Perry Well (170ft. deep, 12ft. diameter) ..	2,000,000
Short Heath Well (130ft., 20in. bore to 400ft.)	2,500,000
King's Vale Well	500,000
	8,500,000

The water of the Aston Well rises 8ft. above the surface of the ground; that of the Perry Well only possesses 9·7 degrees of hardness.

At Kidderminster, with about 20,000 inhabitants, excellent water is yielded from the New Red Sandstone in deep wells, one of them giving 100,000 gallons per day; but, strange to say, the whole of the supply is used in manufacturing purposes, and the domestic supply is entirely derived from dangerously-polluted shallow wells and streams.

A boring of great interest has recently been made at Burford, west of Oxford, which has, after passing through the Oolites and 598ft. of Lias, 10ft. of Rhatic, 291ft. of Red Marls, and 137ft. of Red Sandstone, Conglomerate, and Marl, passed into true coal measures, which continued to the depth in which the boring was obliged to be discontinued owing to the small size of the bore hole. In the Carboniferous beds occurred true coal-measure plants, and a coal seam of some thickness.

Professor HULL, F.R.S., has described, from time to time, the marked south-easterly attenuation of the Triassic and other Lower Secondary strata, and has given the following measurements:—

	Formation.	Lancashire. W'stershire. ft.	Stafford-shire. ft.	Leicester. Warwick. ft.
Keuper Series	Red Marl.....	3000	800	700
	Lower Keuper Sandstone	450	200	150
Bunter Series	Upper Mottled Sandstone	500	150	Absent
	Pebble Beds	500-750	100-300	0-100
	Lower Mottled Sandstone	200-500	0-100	Absent

The distance from the Liverpool district to that of Warwick is about 100 miles, so that the beds have thinned at the following rate per mile:—

	Feet per mile.	
Red Marls	23	
Lower Keuper Sandstone	3	26
Upper Keuper Sandstone	5	
Pebble Beds	6½	
Lower Mottled Sandstone	5	11½

Comparing these results with the attenuation observable between Staffordshire and Warwick, half the distance, the gradient is seen to be very much less:—

	Feet per Mile.
Red Marls	2
Lower Keuper	1
Bunter Beds	9

With these results, the estimated thickness of the Burford beds, 40 miles south of Warwick, should be:—

	Calculated.	Actual Thickness.
Red Marls	620	710
Lower Keuper Sandstone ..	90	428 feet.
Bunter Series.....	nil.	

Proving that the beds have thinned eight feet per mile southwards, more than the amount between Staffordshire and Warwickshire, that the attenuation goes on from the bottom upwards, which result is of some value in endeavouring to ascertain to what extent the Cretaceous rocks and Oolitic rocks of the South of England may be underlaid by the Trias, and especially the water-bearing portion of it.

The new Crossness boring has, after passing through the Gault with its characteristic basement phosphate bed, reached a marl, with coarse partings containing pebbles, which is considered by Messrs. Etheridge, Whitaker, and myself to be probably referable to the Trias, and it is a matter of considerable scientific interest to ascertain its thickness, and the nature of the underlying rock.

If a line be drawn at right angles to the direction of the

line of attenuation of the Trias, through Crossness westwards, it will pass through Reading and Marlborough, from which line Burford is only 25 miles distant, which would give for the Red beds an estimated thickness of 178ft. along this W.S.W. line of strike, which nearly corresponds with the tract that Mr. GODWIN AUSTEN believes the connection of the Belgium and South Wales coalfields to occupy.

The average amount of hardness of the water of the deep wells of the New Red Sandstone, as tabulated by the Rivers Pollution Commission being 17·9°, and of the springs from the same formation no less than 18·8°, the relation of hardness of water to the rate of mortality of the persons drinking it, becomes a matter of great importance.

The Commissioners give three tables of statistics that bear directly upon this point.

From Table I. it appears that in twenty-six towns, inhabited by 1,933,524 persons, supplied with water not exceeding 5° of hardness, the average death-rate was 29·1 per 1000 per annum.

From Table II. we learn that in twenty-five towns, inhabited by 2,041,383 persons, drinking water of more than 5°, but not exceeding 10°, the average death-rate was 28·3 per 1000.

In Table III. we find that sixty towns, with an aggregate population of 2,687,846, drinking water of more than 10° of hardness, the average death-rate was only 24·3.

Of the towns in Table I., none are supplied from the New Red or Permian Formations. In Table II., three are so supplied. In Table III., ten are so supplied.

From which it will be observed that the largest number of towns supplied with New Red water are found in the tables with the lowest death-rate, and the hardest water.

The same result is obtained if we compare towns of corresponding populations and occupations supplied from surface

areas with soft waters, and those supplied by deep wells in the New Red Sandstone. Thus:—Manchester with 351,189 inhabitants has an average death-rate of 32·0 per 1000; while Birmingham, with 343,787, has only 24·4. And again Stirling, with 14,279 inhabitants, has an average of 26·1 per 1000; while Tranmere, with 16,143 inhabitants, has only 18·8.

But it may possibly be objected that the high death-rate of Manchester is not due to the softness of the water supplied to the inhabitants, but to the density of the population, the close proximity to the houses of cesspools and ashpits, and the want of care experienced by children in the manufacturing districts. And, again, that the low death-rate of Tranmere is due to the constant immigration of adults. And that these averages, being dependant on so many external causes—not due to the purity or impurity, hardness or softness of the water supply—is borne out by the facts that Greenock and Plymouth, both supplied with soft water, with an equal number of inhabitants, have a death-rate respectively of 32·6 and 23·3 per 1000, due to the difference of density of population, Greenock only having one house for every twenty-eight people. And, again, Liverpool and Birkenhead, both supplied with moderately hard water, the one an old and densely-populated town, with a site saturated with what is injurious to health, the death-rate is 34 per 1000; while Birkenhead, a new town on an open site with wide streets, has a death-rate of only 24 per 1000, though mainly inhabited by a poor and struggling class of persons.

But, at the same time, it is worthy of note that the five inland manufacturing towns with the lowest death-rate are all supplied with hard water, and all from the New Red Sandstone.

	POPULATION, 1871.	MORTALITY PER 1000 PER ANNUM.
Birmingham	343,787	24·4
Leicester	95,220	27·0
Nottingham	86,621	24·2
Stoke-on-Trent.....	130,985	27·9
Wolverhampton	68,291	25·9
AVERAGE....	144,981	25·5

And again the average death rate of 12 inland non-manufacturing towns, supplied with soft water, was 26·0 per 1,000, while that of 20 similar towns, supplied with hard water was only 23·2. When, however, the mortality of the district, including the principal English watering places, are compared, there appears to be little variation in the death-rate, whether the population be supplied with soft, moderately hard, or hard water; so that it may be safely concluded, that where sanitary conditions prevail with equal uniformity the rate of mortality is practically uninfluenced by the degree of hardness of the water drank, and Her Majesty's Rivers Pollution Commission are of opinion that "soft and hard waters, if equally free from deleterious organic substances, are equally wholesome."

Out of numerous samples of water from shallow wells in the *Lias*, analysed by the Rivers Pollution Commission, from the Midland and Western Counties, only two were found to be fit for drinking and cooking—those of Somerby and Somerton. The total proportion of solid impurity rarely descends below 50 parts per 100,000, or 35 grains per gallon, and mounts up to 215 grains per gallon, the hardness being so great as to render them quite unfit for washing. These waters are also seriously polluted by the presence of animal organic matter, which largely escapes oxidation through the

non-porous character of the Lias, the shallow wells in the more permeable New Red Sandstone being much freer from organic impurity.

The waterworks well at Northampton, 191 ft. in the Lias, yields a very pure water of only 10·3° of hardness, of which 8·6° is temporary.

Springs from the Lias, form all or a portion of the water-supply of Cheltenham; Coaley, Gloucestershire; Grantham; Haydon, near Cheltenham; and Ilminster, Somerset, the waters are hard though clear, colourless, and palatable, and much of the hardness is temporary. The total solid impurity is 36·41 parts per 100,000, or 25.49 grains per gallon. —The temperature of these springs ranges from 8·°2 C to 15·°0 C.

Shallow wells in the *Oolites* at Bedford; Faringdon; Frome, Somerset; Thame; Warkton, near Kettering; and Witney, Oxfordshire, yield very hard waters, with a dangerous quantity of organic matter, which, being chiefly of animal origin, cause several of them to be clear and apparently palatable.

Of deep wells in the Oolites, yielding unpolluted water, may be mentioned those at Scarboro', from a bore 214 ft. in depth, at the Grand Hotel; from a well at Berrywood, Northampton; from the Thames head well, Cirencester (60ft. deep); from a well 120ft. deep at Stowe-on-the-Wold, Gloucestershire,—all yield clear and palatable water. The solid impurity contained in solution, consisting of innocuous salts of lime and magnesia, the average amount being 23·52° grains per gallon. The proportion of organic matter is exceedingly small, proving the Oolitic rocks are not inferior to the New Red Sandstone in the energy with which they oxidize and destroy the organic matters present in the water percolating through them, which becomes bright, sparkling, and palatable, and perfectly wholesome.

The exceedingly permeable character of the Oolites cause them to absorb a very large proportion of the rainfall, which charges the pores and fissures of these rocks with immense volumes of water of a hardness of 20·6°, but capable of being softened at a moderate cost to 5·8°.

Carbonate of lime, of which the Oolitic Rocks are mainly composed, is soluble in water containing carbonic acid, which causes the springs issuing from this formation to contain a large amount of solid impurity, the average being 29·69 parts per 100,000—or 20·78 grs. per gallon—the average hardness being 24°, chiefly of a temporary nature.

From the exceedingly porous, absorbing, and permeable nature of the Oolitic Rocks, they hold a vast store of magnificent water, which is thrown out in springs of very large volume, which, unfortunately, are rarely used by communities until it has found its way into rivers, in which it is hopelessly polluted.

The temperature of the springs ranges from 8°·1 to 11°·8 C., those of Cirencester being generally about 10°·0 C.

Mr. J. Bravender, of Cirencester, has given an exhaustive account of the yield of springs in relation to the geological strata of the Upper Thames basin. Within this watershed, on the south side of the river, occur the Chalk, Upper Greensand, Gault, Lower Greensand, Portland Oolite, Kimmeridge Clay, Coral Rag, Oxford Clay; and on the north side the Oxford Clay, Kelloway Rock, Cornbrash, Forest Marble, Great Oolite, Fuller's Earth, Inferior Oolite, and the Lias.

Of these the following are permeable, and absorb a large quantity of rain :—

Inferior Oolite.	Coralline Oolite.
Great Oolite.	Portland Rock and Sands.
Cornbrash.	Greensand.
Sandy Bed of Forest Marble.	Chalk.

A greater portion of the rain runs off the following strata as it falls:—

Lias	Except when covered with gravel.
Fuller's Earth....	Nearly all runs off. Area very small.
Forest Marble	Quarter runs off.
Oxford Clay.....	Part absorbed by surface gravel, but all reaches the Thames.
Kimmeridge Clay..	Nearly all.
Gault	Nearly all partly reabsorbed by the Greensand.

The rivers Churn, Coln, Windrush, and Evenlode descend through valleys of denudation, the Inferior Oolite being cut through below its junction with the Lias, which throws out in springs the rainfall which has fallen on the Oolitic area above; which rainfall would have been lost to the Thames had not this denudation taken place, for following the dip planes of the strata, it would have been taken many feet under the bed of the river, both as regards the sheet of water supported by the Fuller's Earth and the Lias.

A very large proportion of the rainfall of the Great Oolite and Kelloway Rock descends through these formations to the Fuller's Earth, on which retentive clay is accumulated the enormous quantity of water found passing down the dip planes of the strata, until arrested by faults, which cause a portion of it to issue as springs, the principal of which are

Boswell Spring.
  October, 1864—dry October —yielded 1,1000,00 gallons per day.
Ewen Spring.
Abney Spring.
Bibury Spring.
Ablington Spring.
Winson Spring.

Three intermittent springs:—
  Winterwell.
  Thames Head.
  Thames Head, near Tewksbury Quarry.

In addition to this three million gallons of water is pumped up from the Fuller's Earth by the engine at the Thames Head well, for the supply of the Thames and Severn Canal. The whole of this water would otherwise flow down the dip plane of the strata, and be lost to Thames vale.

The principal loss to the basin of the Thames is in the area occupied by the Inferior Oolite—about 106 square miles. In the river Arun, in three miles run over porous Inferior Oolite, there was a loss of 100,000 gallons per day.

Lyreford spring yields 3,000,000 gallons per day to the river Coln. This river loses much of its water.

The late Professor PHILLIPS suggested the making of embankments across some of the porous beds of the Oolitic tributaries of the Thames above Oxford. It was objected that were the water thus forced back up the dip planes of the strata, it would flow into the deeper valleys of the tributaries of the Severn, on the other side of the *surface watershed.*

Mineral Water of St. Clement's, Oxford.—Professor PRESTWICH, in a paper read before the Ashmolean Society, describes the character of the water now issuing from an artesian bore-hole carried 420 feet through the Oxford clay and Oolitic strata in 1832. An analysis by Mr. Donkin proves this water to contain 1277 grains per gallon, a quantity not exceeded by many of the Continentai saline waters. In the large proportion of *sulphates,* this water most nearly resembles some of the German mineral waters, such as Friederichshall and Rehme, than those of England; for that of Cheltenham only contains 694 grains of saline ingredients, of which 104 grains per gallon consist of *sulphate of soda,* which at St. Clement's amounts to 357 grains.

The escarpment of the North Downs chalk hills of Wiltshire, Oxfordshire, and Buckingham are fringed with springs, some times on the top of the Chalk Marl, sometimes well down in it.

The waters from the *Greensand* and *Hastings Sands* are good and wholesome, though generally too hard for washing; but they can be softened by CLARKE's process. From the porous nature of these rocks the organic matter contained in water passing through is readily oxidized. The protoxide of iron, nearly always occurring in the Greensands, has also a reducing effect on the nitrates and nitrites present in the water, removing their oxygen and transforming a portion of their nitrogen into ammonia. Sometimes, also, the sulphates present are attacked, and sulphuretted hydrogen generated, the odour and flavour of which is observable when the waters are first drawn from the well, and which disappear with exposure to the air.

The deep wells at Ashford, Cambridge, Eastbourne, Folkestone Waterworks, Swanage, Gosport Waterworks, and Ventnor Waterworks derive their supply from the Lower Greensand. The deep well at the Workhouse School near Brighton, through the Chalk and Gault, also reaches this formation at a depth of 1285ft., the water obtained being remarkably soft.

Anticlinal rolls in the South-East of England have exposed the Atherfield clay at the base of the Lower Greensand in some valleys, which throw out very powerful springs at the base of the Hythe Beds, around Riverhead, and Bradbourn, met with in enormous quantities in driving the railway tunnel west of Sevenoaks, it being calculated that no less than two-thirds of the rainfall (28 inches) of this area sinks into the ground.

In the Hindhead, Leith Hall, and Black Down district, Mr. Topley calculates the daily yield of the Lower Greensand at 27 million gallons of water under 1° of hardness, becoming harder as it flows.

The plentiful supplies derived from this formation have been suggested as suitable for the requirements of London,

but unfortunately it appears to narrow its area around the ancient palæozoic ridge underlying the metropolitan area, though 450 feet in thickness in Reigate, and 200 feet in Bedfordshire.

The boring at Meux's Brewery has established its occurrence for the first time in the London district, but it is of an exceedingly compact nature.

Gault.—This formation I found to be 130 feet thick at Folkestone, and to be capable of division into 11 beds or zones characterized by distinct organism. The first and eighth zones consisting of phosphatic seams, the upper seam dividing the Upper Gault from the Lower Gault, the lower seam the latter from the Folkestone beds.

This basement bed was present in the Gault of the Kentish Town well, where the Gault reaches, according to Mr. PRESTWICH (Q.J.G.S., vol. XII. p. 9), a thickness of 101½, at the Crossness well it is over 140, at Arlesay Lunatic Asylum 204, at Hitchin (probably) 214.—(WHITAKER.)

Upper Green Sand.—My colleague, Mr. TOPLEY, has very ably pointed out the relation of the parish boundaries of the South-east of England to the great geological escarpments, due in great measure to the early settlement of these regions on districts affording water supply for our ancestors.

The villages invariably stand at the foot of the chalk escarpment here as in Yorkshire; where the Upper Greensand is present they stand upon it; if absent on the basement beds of the chalk, which form good arable soil, and throw out springs supported by the Gault beneath, the *parishes* invariably ascend the escarpment and extend to the crest, and but rarely descend the slope. This is true of the whole chalk region of England, the long diameter of the area of the parish corresponding to the dip of the beds. This I have found to be also the case in the Vale of the Eden, where the villages occur on the Permian sandstone, and the parishes

extend up the mountain limestone escarpment thrown up by the Pennine fault.

South of the Weald there are no less than 35 villages on the Upper Greensand in Sussex, and 13 in Hampshire, while on the Gault there is only one in Sussex, and none in Hants. No less than 119 parishes ascending the chalk escarpment, their villages lying below it.

The *Chalk Marl* of England is generally rather compact, and of a more clayey nature than the white chalk. No water was found in it in the deep borings of Kentish Town, Harwich, Southampton, or Calais, and in the French and Belgian coalfields it is perfectly impermeable, keeping the water of the upper chalk from the coal-workings. But in England water-bearing fissures sometimes occur like that at Ising cutting (Stephenson), yielding 1,000,000 galls. per day.

The *Totternhoe Stone* is a rather sandy, hard, dark limestone, with occasional dark green grain, and a few hard dark-brown nodules and fossils, forming the top of the chalk marl, about 80ft. above the Upper Greensand; it has been traced by the Geological Survey from Henton, on the eastern edge of Oxfordshire, to near Hitchen, in Hertfordshire.

It follows the windings of the various chalk combs, and is often the water-bearing bed from which many springs at the base of the chalk escarpment rise; it weathers flaggy, and is sometimes quarried in large blocks. It is often in two or more beds split up into soft marl.

Lower chalk, 400ft. to 500ft. thick in Hitchen and district, extends up to the "chalk rock," nearly at the top of the escarpment. Prof. Ansted observes that "the bottom beds of the chalk are usually of lower specific gravity than the upper" (Proc. Inst. C.E., vol. ix., p. 361), and regards the upper chalk as the conductor, and the lower chalk as the containing portion.

The Chalk Marl on the tract between London and Hants Basin, forms a rich soil, suitable to the growth of hops, wheat and clover at Selborne. It was described by WHITE as decomposing into white malm or natural marum.

Mr. BRISTOW describes the chalk between Basingstoke and Mitchedever, and near Andover, as "dry, bare, and open country, comparatively free from the growth of timber in consequence of the absence of drift, which produce a 'more luxuriant and picturesque appearance."

Chalk absorbs the largest proportion of the rainfall of any rock, yielding it in deep wells in a condition of purity from organic matter unsurpassed by any other geological formation; and it constitutes a vast underground reservoir, in which the water is not only kept pure, but is preserved at a uniform temperature of about 10° C. (50° F.), rendering it cool in summer, and keeping it far from freezing in winter.

Every 1,000,000 gallons of water drawn from the chalk carries with in solution, on an average $1\frac{1}{4}$ ton of the chalk, through which it has percolated, causing an additional storage-room for 110 gallons of water; so that the yield of a well draining a given area, other things being equal, ought to gradually increase in yield, until the maximum limit of permeability is reached.

As examples of deep wells in the chalk may be mentioned those at Dover, in the Castle, 367ft. in depth; Great Grimsby, 300ft.; Norwich artesian well 400ft.; Basingstoke, 340ft.; Caterham Waterworks, 490ft.; Deptford Kent Waterworks, 250ft.; Plumstead K.W.W., 600ft.; Sittingbourne W.W., 400ft.; Nettlebed, 378ft.; Tring, Chiltern W.W., 507ft.; Winchester W.W., 200ft.

The total solid impurity dissolved in the water of these and a large number of other chalk wells (in all 66), was 36·88 parts per 100,000, or 25·72 grains. per imperial gallon, but

chiefly consisting of bicarbonate of lime, which is innocuous to health.

Where the chalk passes under the London clay, it becomes more compact, and consequently less permeable, and the character of the water has altered, the total solid impurity averaging 78·09 parts per 100,000, or 54·66 grains per imperial gallon, a large portion of which often consists of bicarbonate of soda.

Prof. PRESTWICH, F.R.S., who, since the publication of his "Inquiry into the Water-bearing Strata around London, in 1851," has continued to add so much to our knowledge on this subject, has pointed out that the dip slope of the Chalk is not in section a straight inclined plane, but some form of variable curve, causing the water-bearing beds to dip towards the outcrop as well as in the direction of the dip, which explains the origin of the numerous powerful springs issuing from the top of the Chalk Marl and Grey Chalk at the base of the Downs, overlooking the older formations.

Where the ridge of the *curve x* is lower than the outcrop of the bed, the water ascends the curve, which, there being no communication with the surface, acts as a syphon, and drains off all the water between *x* and *s*, and the spring ceases to flow until recharged, which explains the origin of the intermittent springs of Lavant, in Sussex; the Bourne, near Croydon; and several at the foot of the Chalk Downs at Folkestone, in Kent.

In Folkestone district, after a careful study of the Chalk

for some years, I think there is a tendency for joints and fissures to disappear in depth, and the lower beds to be more compact and homogenous. Powerful springs like that of the Lydden Spout are rare. The water obtained from the wells of the various farmhouses on the Downs south of Dover draw upon an underground sheet of water travelling down the dip with an exceedingly slow movement, and saturating the lower beds to the extreme limit of their permeability. This surface of saturation is but little above the sea-level in Eastweir Bay, and eventually dips beneath it; and fresh water may be seen issuing between tide-marks on the shore.

The fact that the fissures are rarer and joints less open as lower levels are reached make it exceedingly improbable, even if the sea bottom of the Straits of Dover consisted of bare Chalk, which for the most part is not the case, that any fissures occur which might conduct the sea into the workings of the proposed Channel Tunnel, for which the preliminary headings are now making good progress, though there can be no doubt that the operations being carried on below the limit of *permanent saturation* of the chalk that large bodies of water will be met with.

But this is no insuperable difficulty. For the tunnel for sewerage works, already constructed beneath the sea-level by SIR JOHN HAWKSHAW, no less than 8600 to 10,000 gallons of water were pumped per minute by 12 pumps, worked by engines of 150 horse-power; in the Channel Tunnel it is proposed to provide for 2000 horse-power. The approach to the Tunnel will penetrate the White Chalk at a gradient of 1 in 80, and on reaching the Grey Chalk beneath, in which it is proposed to drive the Tunnel, the water-bearing beds will doubtless be left behind.

The numerous wells sank at or near the sea-coast, as that at Worthing, 400ft. deep; Margate, 374 feet of Upper Chalk; and at Dover Castle, prove the pressure of ocean

water is not sufficient to penetrate the strata, which is still further supported by the dryness of collieries and copper mines worked under the sea, and the plentiful supply of fresh water obtained in the artesian wells sank in the sea at the Spithead Forts.

If the plane of saturation by artificial means were lowered, then fissures or outlets which allow the escape of fresh water at or beneath the sea-level would no longer have sufficient head or pressure to force back the sea water, and the sea would flow in. This has occurred at Calais, where, in an unsuccessful boring for water, a brackish spring was met in the Upper Chalk, at 160 metres, or 70ft., and Paleozoic rocks at 336 metres. These latter rocks in France and Belgium, with their productive coal basins, are protected from the water in these exceedingly porous beds of Upper Chalk by the very impermeable Chalk Marl, which contains a large proportion of argillaceous matter and silicia.

At Folkestone above 6,000,000 gallons are daily delivered, derived in winter from chalk springs, which in summer diminish in volume, and the supply is taken from wells sank through the Gault to the Lower Greensand, which are capable of yielding half a million gallons daily. The water is very hard, no less than 32°, but of a character that would be reduced to less than 8° of hardness by Clark's process, which is now adopted at Canterbury, Tring, Aylesbury, Caterham, Red Hill, and other places with great success for a similar class of water.

It is a curious fact that these hard spring and well waters, though clear and bright when first obtained, become covered with a confervoid growth when exposed to the sunlight in open reservoirs.

In the Thames valley and in those of its tributaries, 1233 square miles consist of impervious clay, and 3676 square miles of permeable strata, of which the most important, as yielding deep-seated and constant springs, are the

Bagshot Sands	211½	square miles.
Chalk	1047¾	„
Upper Greensand	126	„
Great and Inferior Oolite....	327	„

The average rainfall of this area during eleven years was found to be 27·74in., of which only 9·25 was discharged, and no less than 17·30 evaporated, or 66 per cent.; half the discharge being due to springs, or 17 per cent., the other half, to floods.

The discharge from springs is due to the slow percolation through the rocks, and in the case of the chalk is probably not given off till many months after it is received. At Nettlebed, eight miles from the Thames, the head of water in the chalk is 300ft. above the river; from it the line of saturation dips to the river at 37ft. per mile, gradually diminishing to 7ft., according to Mr. HARRISON, who regards the chalk there as an inverted reservoir, from which water will continue to flow until its gravity only equals the capillary attraction of the chalk, which condition does not arise even after 240 days' drought, when the springs remain constant in volume, unlike those of the oolites, which, though they have a rapid discharge in winter, from their not being very deep-seated, diminish largely in summer.

Mr. HARRISON found, in September, 1865, that the Thames received from the chalk over which it flowed no less than 80,000,000 gallons a day.

One-third of the average Thames winter discharge is derived from the oolite of Oxford, and only one-eighth of its summer discharge, showing the rapid discharge from this porous rock receiving a heavy rainfall.

According to Mr. BEADMORE, the chalk springs fall almost to a minimum in November, after a hot summer, when there is no rain in October; but the absolute minimum is not felt until the following September, so that the storing power of the chalk is sixteen months. The constantly-diminishing

springs, not replenished by the winter rain of the year before, which has not time to get down to the lower beds of the chalk, though it feeds the land springs.

The first inch of October rain after a dry summer is lost, taken up by vegetation; surface springs are replenished, and after a week's rain, begin to flow again, as the large spring at Woolmer Park.

The chalk hills north and south of the Tertiary basin of the valley of the Thames around rise to a height of 400ft. to 800ft. above Ordnance Datum, plunging under the Tertiaries at an average elevation of 50ft. to 100ft. The whole of the Tertiary tract being stiff, impermeable clay, the chalk beneath is completely cut off from any possibility of percolation from above, and all water existing in it must have travelled down the dip from the outcrop of the base of the Tertiaries, which extend for a distance of 260 miles, and much of the chalk area beyond this limit is covered with impermeable clay—with flints and boulder clay, especially in Essex, Herts, Berks, Oxon, and Buckinghamshire. Probably much of the rain falling on these tracts is absorbed by the bare chalk on the sides of the hills and exposed in the valleys, and even in districts that are bare of drift, though the chalk is exceedingly porous, and will absorb two gallons to the cubic foot, or one-third of its bulk, and its surface cracked and fissured, it is probable that no extensive percolation of rain takes place until after long-continued rains have saturated the first few feet of chalk beneath the vegetable mould that water sinks down to low levels The water that lodges on the surface held by capillary attraction is doubtless returned to the atmosphere by evaporation or indirectly through the vegetation, which PROFESSOR PRESTWICH points out in the origin of the permanent verdure of the chalk downs, notwithstanding their dryness.

The line of saturation, or plane of chalk fully charged with water, slopes from the level of the outcrop of the

impermeable beds supporting the water, in the direction of the dip of the strata, but not always exactly to an equal amount, the gradient being modified by the area of local supply, lithological character of the beds, intercepting influence of faults, numbers of joints and fissures, collecting and conducting the water, and other circumstances. In Herts, according to the Rev. Mr. CLUTTERBUCK, the slope is 13ft. per mile from Dunstable to Watford.

When valleys have been cut sufficiently deep, the water-bearing stratum is reached, and from what have been called "areas of overflow," in which the rainfall absorbed by areas at higher elevations is yielded in springs, which feed numerous streams. In artesian wells sank in these tracts the water rises to the top of the boring, and often much above it, as at Kingston (Hodgson's Brewery,) the water rose 6ft. above the surface, or 31ft. above Ordnance datum. The large numbers of wells that have been sunk in the metropolitan district during the last fifty years have caused a permanent depression, and the demand being greater than the supply, large numbers of springs have ceased to run and wells to overflow, and the volume of those still running have much diminished. In consequence of the steady fall, the engines of the Croydon Waterworks have had to be lowered 20ft.

There are numerous wells of this class in London, amongst which may be mentioned that at the National Gallery, Trafalgar Square, 383 feet deep; at the Royal Mint; at Barclay's Brewery, 367ft.; at the Midland Railway Station, St. Pancras, 300ft.; at the Albert Hall, 401ft.

Of wells of the same class, in other districts, may be mentioned that at Witham in Essex, 600ft. in depth; that at Braintree, Essex, 430ft.; and Harrow, 408ft.

The additional impurity in the waters from the chalk, overlaid by the London clay, is probably derived from the Lower Tertiaries—Thanet Sands and Woolwich Beds—which occur between the chalk and clay.

Both in deep wells, in the chalk, and in other formations, the water is sometimes polluted, through soakage from the superficial deposits around the shaft of the well, or through open fissures in the rock through which the well is sunk; but in all cases the result of analysis show that the water had gained access to the well without the purification which invariably results from the passage of water through a thick stratum of porous and aërated rock. Amongst wells of this class in the chalk may be enumerated that at Carisbrook Castle, S.W., 240ft. in depth; Gravesend Railway Station, 70ft.; Great Bookham, Surrey, 101ft.; Harwich, 380ft.; Colchester, 400ft.; the latter being in chalk under the London Clay.

Position.	Formation.	Depth. feet.	Temperature. Centrigrade. Degrees.
Brighton	Chalk	160	9·6
		100	10·0
Bury, St. Edmond's	—	—	5·0
Canterbury	—	—	10·8
Deal	—	115	11·3
Dorchester	—	130	8·3
Dover	—	220	11·3
		367	13·0
Dunbridge, Hants	—	169	11·5
Great Grimsby	—	300	11·5
Hull	—	—	11·5
Ipswich	—	—	9·0
Ramsgate	—	100	10·0
Amwell, N.R.C.	—	—	11·0
Basingstoke	—	340	11·2
Belvidere	—	70	11·5
Wheathamstead	—	175	10·3
Bushey Station	—	249	10·0
Caterham Works	—	490	11·2
Crayford K. W. Co.	—	200	11·4
Croydon	—	—	13·5
Deptford	—	250	12·2
Gravesend	—	200	9·7
Nettlebed	—	318	10·1
Plumpstead	—	600	12·0
Kidmore End, Reading	—	180	8·3

At Calais, the Cretaceous strata runs directly on the Carboniferous, at a depth of 1032ft.; at Guines, in Devonian, at 674ft.; at Ames, French Flanders, on coal measures, at 424ft., so that the denudation preceding the Cretaceous era, especially that portion lying below the Gault, was very extreme; and it is worthy of note that the Gault is the lowest member of English Cretaceous era over a large area in the south-western counties, where it rests transgressively on older and older beds. At Black Ven it has thinned away to a part or representation of the Upper Gault only.

In the Crossness boring the Gault is present in great force, and its basement bed well marked, resting on what I consider, with Messrs. Etheridge, and Whitaker, to be part of the Triassic series, reaching a thickness of 428ft.

From our traverse of the water-bearing strata of England we arrive at the conclusion that several millions of our population live on areas capable of being supplied with immense stores of pure waters contained in the Permian and New Red Sandstones, the Lower and Great Oolites, the Greensand, and the Chalk, though this population is at present suffering all the ills resulting from a polluted water supply.

2.—That in the case of the Chalk in the Valley of the Thames great care should be exercised in extracting any large volume of water by means of deep wells from the underground springs, from the fact that these maintain the steady dry-weather flow of the river, to which great damage might be done by any permanent lowering of the saturation line, like that which has taken place through excessive pumping in the Metropolitan area.

APPENDIX I.

APPENDIX II.

Hardness of	Degrees.	Average.
Rain Water	0 to 10°	0·49
Water from Igneous Rocks	0·8 „ 5·9	2·4
Lower Green Sand	4 „ 44	4
Metamorphie, Cambrian, Silurian, Devonian, Millstone Grit, London Clay and Bagshots	0·4 „ 32·5	5·6
New Red Sandstone (t. h.)	0 „ 19·8	7·7
Coal Measures	2·3 „ 75·0	14·7
„ (permanent hardness)	1·2 „ 48·5	9·6
Mountain Limestone	9·8 „ 27·9	15·7
„ (p. h.)	3·3 „ 12·9	7·1
Oolites	12·4 „ 38	23·3
„ (p. h.)	3·5 „ 13·5	6·2
Chalk	10·4 „ 50	26·4
„ (p. h.)	2·7 „ 13·8	6·2
Lias	10·3 „ 50·0	29·0
„ (p. h.)	1·7 „ 17·0	8·2
Magnesian Limestone	14·7 „ 67·3	41·2
	8·3 „ 40·8	24·8

APPENDIX III.

VARIOUS WELLS.

NEW WELL.

CROSSNESS JUNCTION OUTFALL WORKS.

(W. Whitaker, Mem. Geol. Survey. London Basin.)

	Feet.
No details of top part.	
River Drift—Gravel .....to	39
Woolwich Beds 47ft.	
Very hard stiff blue clay.....	2½
Stiff yellow clay and sand layers	2½
Hard sand, with layers of tenacious clays of various lime	7½
Hard sandy clays.....	8½
Very stiff hard clay .....nearly	6
Dark green sand	4
Dark green sand, with pebbles of various sizes..over	4
Green clayey sand, with and without pebbles.....	12
Thanet Sand 51 feet.	
Thanet sand .....over	50
Green flints .....nearly	1
To chalk.....	137
Chalk. (Should be more?)	631
Upper greensand. (Should be less?)	65
Gault. (Phosphate at bottom. Specimen at Board Works).....	170
	1003
Red Rocks :—	
Sandstone, very hard	13
Grey sand.....	4
Red marl rock	18
Grey sand rock.....	4
Red marl, with blue vein	3
Brought forward.....	1045

	Feet.
Carried forward	1045
Grey marl	2
Grey sand	2
Grey sand rock	11
Red marl, with blue vein	2
Left of September, 1877	1060

CROSSNESS JUNCTION OUTFALL, OLD WELL.

(W. Whitaker Mem. Geol. Survey. The London Basin.)

Allumium 22½ feet.

Alluvial deposit	1½
Light brown clay	3¾
Blue silty clay with vegetable matter	2½
Peat, with remains of trees	6¼
Dark grey silty clay	1½
Thin layers of peat and clay, decayed wood	1½
Dark grey silty clay	2½
Silty sand	2
Valley Drift and Oldhaven Beds.	
Grey subangular flint gravel, sometimes runnings and with iron pyrites	49
Oldhaven Beds or Woolwich Beds.	
Sand with flints, shells very hard	11½
Fine sand, with flints, pebbles, and small shells	4½
Woolwich Beds:	
Fine green sand	1½
Fine grey sand, with small pebbles	2¾
Fine dark sand and flint	9¼
Fine light sand	35½
Sand bound together by iron	5
Loam and pebbles (? green coated flints)	1½
To Chalk	143½

	Feet.
Brought forward	143½
Layers of flint	0½
Chalk, with layers of flints, at first about 8 feet apart, then from 2½ to 6 feet apart	446
Chalk marl? with fine flint	200
(Upper greensand) Sandy green marl	12
Gault clay	148
	950

CROSSNESS WELLS.

	OLD WELL. Feet.	NEW WELL. Feet.
Surface of the Gault.....	802	829·6
„ „ Chalk	138½	133·6

Boring made by the Diamond Boring Company at Pump House, near Burford, Witney :—

TOTAL DEPTH.		STRATA.	
38		Surface Blue Clay and Pebbles. Lost Water at 38ft.	
90	2	White Lias.....	1ft.
		Blue Lias	1ft.
		Lias.....	9ft.
		Freestone.	
		Black Limestone.	
		Limestone.	
148	7	Clay at 90ft. 2in. Blue Clay with Fossils.	
174	8	Do. with Fossils at 148ft. 7in. Light Lias. Hard Lias.	
186	8	Dark Green Lias with Fossils, at 174ft. 8in	

Total Depth.		Strata.	
		Clay at 186ft. 8in.	
		Do. with Pebbles.	
349	0	Do. with Stone binds.	
		Do. Shells.	
		Harder Clay.	
		Clay with Metal.	
420	0	Do. with Stones.	
		Do. Pebbles and Fossils.	
479	10	Clay.	
496	4	Do. with Minute Fossils.	
502	0	Blue Lias Stone at 496ft. 4in.	
		Blue Claysofter.	
572	0	Very soft Clay.	
		1" Stone.	
600	0	Blue Clay.	
616	3	Greenstone at 610ft.	
		Blue Clay.	
702	0	Hard Lias Clay.	
		Clay as before, Stonebinds.	
717	0	Hard Gully Limestone at 702' 4".	
		Limestone and Shale.	
723	7	Soft Shale at 717' 0".	
746	10	Soft Blue Clay as before, 723' 7".	
749	0	Black Shale, 1 foot.	Rhœtic.
750	0	Green Marl, 6 feet.	
756	0	Gritty Sandstone.	
		Green Marl.	Trias.
821	3	Variegated Marl.	
		Conglomerate.	
972	8	Variegated Marl.	
		Red and Blue Marl Gypsum.	

Total Depth.		Strata.	
1047	0	Red Marl and Gypsum.	Trias.
1172	7	Red Marl. Conglomerate. Marl and Sandstone.	Trias.
1174	0	Red Sandstone.	Trias.

1184 8 Dark Shale at 1180 feet.
1196—1205 Pale Sandstone with plants.
1205—1213 Coal Measure Duns.
1213—1244 Coal Measure.
1244—1284 Red Sandstone and Clay.
1284—1308 Red sandstone.
1284—1295 ,,
1295—1308 ,,
1308—1350 Argillaceous shale.
1350 Coal seam.
1358—1368 Alternations of Duns and fine grained Sandstones (calcareous).
1368—1380 Red and green mottled Sandstone, with fine grained sandy bed.
1380—1391 Red Marls and occasional sandy beds.
1391—1402 Fine grained Sandstone.
1402—1409 Red Marls, &c.

Abstract:—

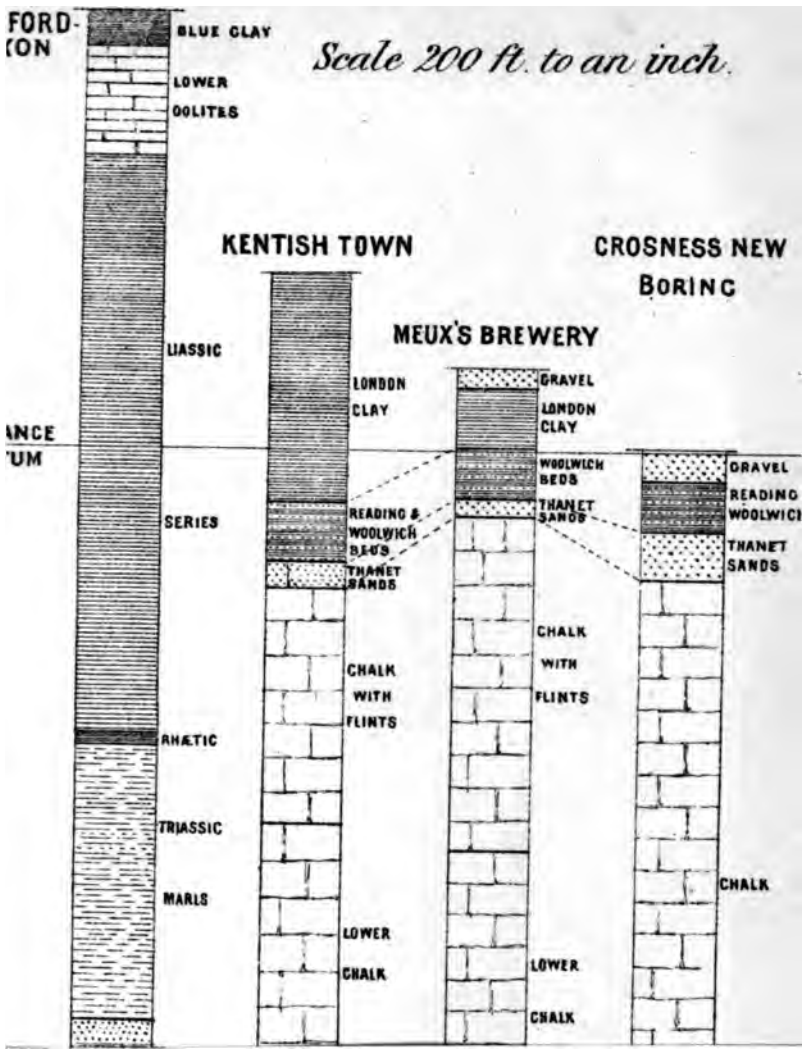
Oolites..... 148.
Lias ..... 148—746.
Rhœtic..... 746—756.
New Red Marls ..... 756—1047.
Red Sandstone.....1047—1184.
Coal Measures.....1184—1409.

TOTTENHAM COURT ROAD (MESSRS. MEUX), LONDON.

	Feet.
Gravel	21
London Clay	63½
Woolwich Beds	51
Thanet Sand	21
Chalk with Flints	347½
Chalk without Flints	305
Upper Greensand	28
Gault	160
Lower Greensand	67
Mottled red and purple green Argillaceous and Micaceous Shales (Devonian fossiliferous	80
	1144

Journal published by the Diamond Boring Company. The fossils from which the age of the various beds have been determined were examined by Mr. Etheridge, F.R.S., to whom I am indebted for an opportunity of looking at the specimens. To Mr. Gulland, of the Diamond Drill Company, the Engineer in charge of the work, and of the Subwealden Exploration, my thanks are also due.

In writing this paper, I have availed myself of the stores of information in the Sixth Report of the Rivers Pollution Commission, the Report of the Rivers of Commission, and the Minutes of Evidence, the Memoirs of the Geological Survey, especially the work of Messrs. Whitaker and Topley, the reports I have drawn up for the Underground Water Committee of the British Association.


FORD-
ON
ANCE
UM
BLUE CLAY
LOWER
OOLITES
LIASSIC
SERIES
RHÆTIC
TRIASSIC
MARLS
Scale 200 ft. to an inch.
KENTISH TOWN
LONDON
CLAY
READING &
WOOLWICH
BEDS
THANET
SANDS
CHALK
WITH
FLINTS
LOWER
CHALK
MEUX'S BREWERY
GRAVEL
LONDON
CLAY
WOOLWICH
BEDS
THANET
SANDS
CHALK
WITH
FLINTS
LOWER
CHALK
CROSNESS NEW
BORING
GRAVEL
READING
WOOLWICH
THANET
SANDS
CHALK

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XX. VOL. XIV. SESSION 1877-8.

At the ORDINARY MONTHLY MEETING of the Members of the Society, held on Tuesday, the 30th April, 1878, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., President, in the Chair.

THE GEOLOGY OF THE ARCTIC REGIONS.

Mr. DE RANCE, F.G.S., said he thought it was possible that some of the members present might like to know something of the Geological results brought back to us by the naturalists of the late British Arctic Expedition. He had the good fortune to be associated with Captain Henry Feilden, the naturalist of the senior ship, in working up the geological results for the Geological Society of London, which had been communicated to them by permission of the Lords of the Admiralty.

Captain Feilden, F.G.S., brought home some 2000 specimens of rocks and fossils, some of which were laid before the Geological Society of London at its last meeting. From the specimens so brought back, and the observations which he made, geologists were able to perceive that the Laurentian

rocks, which occupy so large an area in North America, and extend northwards under the Parry Archipelago, form the sub-stratum of all the rocks of the more northern district—underlying alike the Silurian Limestone of the Parry Archipelago, the Cretaceous rocks of Disco Island, the Oolitic rocks on the coast of East Greenland, and various other overlying rocks which occupied different positions of the Polar area. Above these Laurentians, in the Arctic Archipelago, we knew of Upper Silurian rocks, with fossils; but from the fact of no Lower Silurian forms having ever been brought from thence, the late Sir R. Murchison was led to argue that no Lower Silurians were present in the Arctic area, and more than that, that the whole of the district was dry land during the time occupied in the deposition of the Lower Silurian in other areas. The expedition under Sir G. Nares had disposed of the theory, for the Silurian limestone of Cape Hillgard contain not only Upper but also Lower Silurian fossils, of well-marked species, some of which species, moreover, had already been obtained by the previous expeditions under Mc.Clintock, Sherard Osborne, and others, in the Parry Archipelago. The late expedition, therefore, had not only the merit of proving the existence of Lower Silurians definitely in the area searched by them, but also of showing, by inference, that they were present in the Parry Archipelago. In Kennedy Channel, still further to the north, they came upon rocks which were more ancient—they were older than the Silurians, but newer than the Laurentian—probably being equivalent to the Huronian rocks of America. That, however, was doubtful, from the fact of their containing no fossils. Captain Feilden and the speaker gave them the name of the Cape Rawson beds. The boundary betwixt those old Huronian rocks, if they were such, and the older Laurentians, struck across Kennedy Channel; so that the Silurians reappeared

on the Eastern shore; and from measures at Offley Island, a large assemblage of fossils had been procured.

Then north of those Cape Rawson beds, in Feilden Peninsula, there had been found an extensive outcrop of Carboniferous Limestone containing some fossils which had been found in the Carboniferous Limestone of this country, and—what was exceedingly interesting—having a very strong resemblance to the Carboniferous Limestone of the Parry Archipelago. This limestone struck to the south-west, along the range of mountains called the United States Range, and, continuing the line of this range towards the Parry Archipelago, it would be found exactly to cut the place where the Carboniferous Limestone had been so well worked by Captains Sherard Osborne, Mc.Clintock, and others. It also struck Spitzbergen, and there they found the Carboniferous Limestone, containing many species obtained by the late Arctic Expedition in Feilden Peninsula.

Underneath this limestone the late expedition had found Devonian rocks, and these for the first time were known within the Polar area. There were certain red sandstones in South Greenland, supposed to be Devonian, but they had no fossils; others in Spitzbergen, supposed to be of that age, but they, too, were destitute of fossils; and the coal-bearing beds underlying the Carboniferous Limestone of the Parry Archipelago and Melville Island were supposed by some people to be Devonian, and by others Lower Carboniferous; but any true marine Devonians were never known in that area until this discovery. The fossils found were not only characteristic of the Devonian, but several of them were new, and the late expedition had the merit of finding several species of mollusca which were absolutely new to science.

Then, the expedition found in Lady Franklin Sound a

deposit of Miocene shales, with a 30ft. coal seam—a specimen of which he (Mr. De Rance) had the pleasure to exhibit before this Society last year. Further south, in Greenland, they had certain Cretaceous beds, with two sets of plants: the upper beds containing plants which were characteristic of the lowest portion of the Cretaceous rocks of America, and indicative of temperate conditions. In America, above those Cretaceous rocks they had an extensive series of Tertiary beds, the bottom ones of which contained a series of different floras. The lowest flora indicated sub-tropical conditions. Now, that sub-tropical flora was entirely absent from the Arctic area, and a more temperate flora was represented in the Miocenes of that region, indicating that in Miocene times, though they had not the cold now obtaining at the Poles, the country was even then colder in advancing from south to north.

He (Mr. De Rance) feared he was taking up too much time in bringing this subject before the Society, but he wished, in conclusion, to point out to the Society some important bearings which he thought the results of the expedition had upon glacial matters. They had heard a great deal about ice-caps of great thickness, which were supposed to have over-ridden this country, with a couple of hundred feet of drift between the ice and the underlying rock. There was therefore great interest attaching to the actual observations of men who in the Polar area had seen an ice-cap at work. In Petermann's Fiord ice covered the country to the thickness of only 40ft., and between the base of the ice-cap and the rock there was no extensive deposit of material. From the top of the cliffs, the overhanging ice broke away fragments of rock, which tumbled down to the floes beneath and was carried seaward. But on the western shore of Kennedy Channel they had not even that 30 or 40 feet of ice-cap, in the most northern part

yet reached. The climate was absolutely so cold, and the atmosphere so destitute of moisture, that little fresh-water ice was found. Not only was there no ice-cap in that area, but the glaciers were so small that they could not even reach the sea.

The PRESIDENT asked if it was quite satisfactorily established that the coal found in the Arctic area was of the modern formation named by Mr. De Rance.

Mr. DE RANCE said he thought so. The observations of Professor Heer, who was bringing out an extensive monograph on the subject, proved that the plants were characteristic of the Miocene.

Professor DAWKINS said, with regard to the Miocene age of this Arctic coal, he thought there could be no possible doubt. Professor Heer and others have shown years ago that in various places in the Arctic regions coal occurred, and coal made up of a flora which was not only now existing in America, but was also to be found fossil in the Miocenes of Europe. A great feature which was characteristic of the flora associated with the coals in the Arctic regions was the absence of evergreens, and some of the warmer forms of vegetation. He would say, moreover, that the discovery of this group of plants which Mr. De Rance had brought before the Society was not altogether new, and not wholly due to the late Arctic Expedition. Many years ago the researches that were carried on in Spitzbergen, Iceland, and elsewhere, as recorded by Professor Heer, had shown beyond doubt that in the Miocene age there was no glacial cold in those parts; but the climate was very much of the same sort as was found now in some of the lower regions of Switzerland. That was a point which was satisfactorily established long ago, by Professor Heer. With regard to the other question which Mr. De Rance had put before them, he thought it was extremely interesting to hear that we were

no longer to be in mortal dread of the extreme glacialists. A good deal had been written during the last few years about ice-caps. It was even held by some that a great sheet of ice developed itself in the Atlantic and the North Sea, and prevented any fresh water from finding its way into the sea. He thought when they went to the Arctic regions, and realised that there were no such great sheets of ice, miles thick, geologists might dismiss those speculations which asserted that there were miles of ice covering not only this country, but also the greater part of Europe, and occupying the bed of the sea, without any further consideration. It was to his mind very atisfactory to have arrived at that fact. He for one never believed in pushing the glacial theory to the extreme; and now, when Arctic explorers told them there were no such masses of ice to be found in the Arctic regions, he, for one, must decline to believe in any such speculations as those which were advanced in "The Great Ice Age," and "Climate and Time" the recent works on the subject.

Mr. Rooke Pennington said he believed it had been well recognised that the coal of the Arctic regions was of Miocene age. He believed there was a large deposit of Miocene coal on the banks of the Mackenzie river, which, if not within the Arctic circle, was within a short distance of it. Miocene coal also occurred on the northern coast of North America, between the mouths of the Mackenzie and Coppermine rivers. He asked Mr. De Rance whether any traces of Liassic fossils had been found so far north. They were found by Mc.Clintock and others near the coast of North America, and in Prince Patrick Island, or at all events in the neighbourhood.

Mr. De Rance said the late expedition did not find any Liassic deposits. The farthest north known was a patch of lias resting on Eglinton Island, a little islet north of the

Parry Archipelago, and immediately south of North Cornwall, which was apparently a portion of Ellesmere land. He (Mr. De Rance,) did not bring forward the fact of Miocene beds being specially new, but the results extended them further north than they were known before, and, as Professor Heer himself pointed out, were interesting as the species became more northern in character as we proceed towards the poles.

THE SECONDARY ROCKS OF ENGLAND AS A SOURCE OF WATER SUPPLY.

The paper read by Mr. De Rance at the Ordinary Meeting of the Society, on March 26th, was taken for discussion.

Professor DAWKINS said the very interesting paper by Mr. De Rance opened up a wide field—so wide, indeed, that he hardly knew where to begin. The question of water supply, as they all knew, was one of exceeding importance, not merely to the city of Manchester, but also to people outside the Manchester radius; and he thought Mr. De Rance had done well, in putting before them a few of the main principles on which that question could be dealt with. He had also done well in avoiding landing them into all manner of details which had nothing whatever to do with the main principles of the question. So far as Mr. De Rance's paper struck him, it might be divided into two parts, that was to say, that aspect which was of exceeding importance, from a sanitary point of view; and secondly, that part which was of exceeding importance so far as related to the amount of water which was to be obtained from the rocks.

First, then, as regarded the sanitary question. He supposed that no one who really reflected upon the present condition of the water supply in this country could be ignorant of the fact that there was scarcely anything about which people were so utterly careless. Supposing, for example, we took an ordinary house, on a hill slope composed of coal measure rocks, mill stone grit, or any other rocks containing water. The front of the house will, as a rule, look towards the valley, and the back extend up the hill slope. What was the mode in which this typical house is supplied with water? As a rule, a pump is placed close to the back door, and a little way from it, up the slope, there is a cesspool. That was the rule in the case of houses built upon a slope. The result was this: the level of the water in the permeable rock roughly conformed to the surface of the ground, and the water found its way down towards the centre of the valley. Refuse water and other matters were always being thrown into the cesspool, whilst, at the same time water was being taken from the well. Under these conditions the water from the cesspool finds its way directly into the well by the ordinary laws of gravitation. In other cases where houses were built upon the flat, say on gravel or sand—they might take Oxford as an example. where they had the Oxford clay below and a layer of gravel above—the wells are sunk into the gravel and cesspools are constructed close by. Here again, from the fact of refuse water being constantly thrown into the cesspool, and water taken from the well, there was a continual gravitation of material out of the cesspool into the well: hence typhoid and scarlet fevers, and other diseases which were the horror of sanitarians. This was a point of exceeding interest to people in this part of the country, because he was sure many of them were aware of numberless little hamlets on the hill sides or valley bottoms, where the air was perfectly pure,

where everything was just of a sort to furnish the most perfect health to the inhabitants, and yet there were many such places suffering from chronic attacks of fever and sore throat.

Mr. De Rance entered into the question whether hard water was more conducive to health than soft; and he agreed with him that it was six of one and half-a-dozen of the other. Other things being equal—the air being pure and sewage absent—hard water apparently was quite as good to drink as soft water; at all events a careful analysis of the evidence upon this question by Dr. Angus Smith fully confirmed what had been put before them by the Commissioners, who had inquired into it on behalf of the Government.

With regard to the second question—as to what amount of water was contained in the secondary rocks—he would also just make a few remarks. He exhibited a map which was published by the Coal Commissioners to show the coal measures, and he had brought it in order to point out the cause of the enormous supplies of water that were obtained from the New Red Sandstone in the area of Lancashire and Cheshire. In treating of the Liverpool supply, Mr. De Rance said it was perfectly obvious that the water was derived from some area outside that of Liverpool. When they reflected that this area of New Red Sandstone, with the Red Marls, ranged as far to the east as Manchester, and into Staffordshire, and southwards as far as Shrewsbury, resting in a basin of older rock, and that the older rock was, for the most part, of such a nature that it might be looked upon as impervious; when they reflected also that the great basin had a notch broken out of its rim, extending between the coal measures of St. Helen's and the mouth of the Dee, then they had a sufficient explanation of the fact of an enormous body of water gravitating seawards through that

notch. Moreover, when they realised the enormous quantities of water obtained in Manchester, which was on the edge of the basin, no doubt could exist as to there being vast quantities of water in the New Red Sandstone, and that we had there a source of supply which was of the very highest importance.

Nevertheless, although he thought that that head of water might explain—in all probability did explain—the enormous quantities of water furnished by certain wells in Liverpool and the neighbourhood of Manchester, yet he did not altogether feel justified in thinking that that was the best possible source of supply for a great city like Manchester. The water in the New Red Sandstone was, as a rule, very hard. It might or might not contain other substances besides carbonate of lime and salts of iron. It might contain, and did in some places contain, large quantities of chloride of sodium. However that might be, there could be no doubt that wherever the New Red Sandstone did occur, there they had a great reservoir, from which they could obtain water by sinking into it, for the water in the Red Sandstone percolated between the grains of quartz, of which it was largely composed, with a freedom varying according to the coarseness or fineness of the rock He mentioned that fact because it opened out another question.

Mr. De Rance, in his paper, compared the enormous amount of water which undoubtedly exists in the chalk with that which existed in the New Red Sandstone. Now it seemed to him that there was this point of difference to be observed regarding the two sources of water supply. In the New Red Sandstone you may sink a well almost anywhere and on reaching a certain level you get water. He did not know of a deep well in the New Red Sandstone, at all events in this area, which had not furnished water. But the water in the chalk was on a totally different footing. From the ex-

periments which had been conducted by Professor Ansted and others, it appeared that water in the chalk flowed mainly from crevices and fissures. It was a well assertained fact that there was scarcely any direct circulation of water through the mass of the chalk itself, and that fact was shown not merely by experiments in the laboratory, but it was shown by the large number of cases in which deep wells had utterly failed to furnish water in the chalk. In the chalk, as in the New Red Sandstone, there was a level of saturation, but the sandstone parted with its water with comparative freedom, whilst the chalk did not. For every cubic foot of chalk you had from two to two and a-half gallons of water, locked up in capillary pores, and although the water was there, you could not obtain that water for the supply of wells. Supposing you take a cubic foot of chalk, and dry it, it will absorb two or two and a-half gallons, and the water so absorbed could not be extracted from the chalk, except by the process of evaporation. With regard to the effect of pressure in expediting the passage of water through the pores of the chalk, he did not think it could be said that pressure exerted any great influence, because if that were the case in deep wells in the chalk, the deeper you go below the level of saturation the more water ought to come out. This was not so. Further, Prof. Ansted has shown that by charging a column of chalk with water and then doubling the height of the column no appreciable difference is to be observed with regard to the amount of water flowing out through the bottom of the column. Therefore the effect of pressure was comparatively small, so far as it expedited the passage of water through the chalk; and that was a most important consideration. It was a consideration which lay at the very root of the comparison between the water supply in the Red Sandstone and that in the chalk, because in the former there was a supply which

could be got at; whereas in the chalk, they might get water if they hit the series of fissures in which it was stored up, but on the other hand if they did not hit on those fissures they might sink right through the chalk and not get any water. Those were the principal points which occurred to him, in discussing the important paper by Mr. De Rance, which opened an almost endless avenue of discussion.

Mr. Rooke Pennington said it was very important that they should be able to ascertain the precise value of the chalk as a water bearing formation. There could be no doubt that for a very considerable period,—in fact from the remotest antiquity large populations had drawn their water from the chalk supplies, because it was well known that the geographical positions of numerous villages in the southern counties was partly determined by the flow of water from chalk escarpments. At the same time he presumed it was possible that that might also have been determined by the existence of faults or fissures in the chalk, which had allowed means of escape for the superabundant water after the chalk had become saturated. Mr. Pennington referred to the tables of rainfall in different districts, given by Mr. De Rance, and said that they required correction.

The President said he might just call attention to the section which was made through the lias at Scarle, near Lincoln, a couple of years ago. Mr. Boote, Engineer, who had the superintendence of the bore hole, favoured him with a copy of the section. He asked Mr. Boote whether in passing down through those rocks,—which to his mind were the same as those bored through to the rock salt at Middlesborough,—any rock salt was met with. Mr. Boote said if such had been met with he was not aware of it, but that probably some had been passed through. He (Mr. Dickinson,) would like Mr. De Rance to say whether he had

any knowledge of rock salt having been met with in the bore hole, as it seemed to have gone down thro' the Permian beds, and it was in those beds the rock salt was met with at Middlesborough and at Port Clarence, on the opposite side of the river. He (the President,) would also like to ask Mr. De Rance for some description of the data upon which it had been asserted that the boring at Meux's brewery, in London, went down into the Devonian purple and green shales,—whether it was upon the lithical character of the rock, or upon the fossils that that conclusion had been arrived at. He had no doubt there was some good ground, and it would be satisfactory to the Society to know what that ground was. As Professor Dawkins had said there were so many points of detail in the paper that one could only lay hold upon one or two in the course of discussion. It was a very useful paper for reference.

Mr. De Rance said with regard to the boring at Meux's brewery he had had an opportunity of examining the cores that were brought up. They were kindly shown to him by Mr. Etheridge, who identified species of mollusca as Devonian forms — the same forms which were known in the Devonian rocks of Devonshire and in the Rhine country. There is therefore no doubt that the Devonian was reached at Meux's brewery. In all the other deep borings in the London district unfortunately no fossils had been found in the doubtful rock which underlay the cretaceous series, with this exception; but these were so well marked, and so well preserved, that the absolute specific name could be given to the several forms. With regard to the boring at Scarle, he quoted the paper of his colleague, Professor Hull, published in the transactions of the Institute of Civil Engineers. Of his own knowledge he knew nothing of the particulars obtained by Mr. Boote, the Mining Engineer, at Scarle. He was inclined to think that

no bed of rock salt was found, but at that point he had really no definite information. With regard to Professor Dawkin's remarks, he in a general way agreed with him, that there was a basin of new red sandstone which absorbed a large amount of rainfall—some 8 or 10 in. every year—in the district of Lancashire and Cheshire; and it was supported by certain palæozoic rocks, which were practically impermeable; but looking on the whole he slightly dissented from Professor Dawkins in thinking that the enormous yield of certain wells—or of a particular well—at Liverpool, was due to any special body of water travelling down that basin towards the sea; because it seemed to him if the water were in transit to the sea, and were especially obtained from that particular supply, at Liverpool, then similar wells, at other points along the path which it would travel from the Manchester coalfield towards the sea would get equal amounts. But at Prescot and in the district of Garston, and also at Winwick, near Warrington, the exact quantities of water obtained on an average, month by month, were known; and they knew for a fact, that at the Whiston pumping station the withdrawal of 800,000 gallons per day had affected the wells for a distance of a mile and a quarter, and even, he thought for a mile and three quarters around. If there was a practicably inexhaustable supply travelling down the dip lines of the strata, it seemed to him Prescot ought to have the first pull before Liverpool; therefore the enormous yield of certain corporation wells, at Liverpool, must be due to some special causes connected with fissures in which water freely travelled applicable in that special area; and in that way, he thought possibly the chalk was comparable with the New Red Sandstone. He did not know, however, that he went into any direct comparison of the chalk with the new red sandstone as water-bearing strata. There was an essential difference between them, water travelled much more

freely in sandstone—New Red or any other sandstone,—or sand, than it did in chalk, and the chalk, whilst it absorbed a large quantity of water certainly did not yield it with the rapidity which sandstone did, *en masse*. In various districts large bodies of water were yielded by vents and fissures in the chalk; and how important that was, as a water bearing formation, was proved by the fact that in dry weather the flow of the Thames was absolutely dependent upon the water which after being absorbed in the chalk was given up in springs. In regard to Manchester, he had never recommended a supply from the New Red Sandstone; but, on the contrary, he had always held that though soft and hard waters are equally wholesome, it is dangerous to the health of a community to substitute a water supply of the one character for that of the other.

SINKING OF SURFACE OWING TO WORKING OF COAL MINES.

Mr. W. J. Grimshaw, F.G.S., read the following paper: It was resolved that the discussion upon the paper should be deferred until it was in the hands of the members.

Mining engineers have often to solve to the best of their ability a problem which is ever varying in conditions as regards details. Coal underlies tracts, the outer surface whereof and the erections whereon require to be supported or undisturbed. As a rule under such conditions, the coal can only be partially gotten, and most colliery proprietors and mining engineers take extremely good care to leave enough coal to support the surface. If they err, it is generally on the safe side. Mines are worked at different depths: the thicknesses vary, the rates of inclination vary, the nature of the roof and the superincumbent strata differs,

and the conformation of the surface and the character of it are seldom the same in any two cases. Where differing conditions exist, differing results must ensue from similar operations carried out under the said differing conditions. The result is an unknown quantity, which cannot infallibly be found by the guidance of theory or that of practice. Theory and practice go hand in hand as regards mining operations; by their mutual aid we may hope for reasonable success, but divided and exclusive they are worse than useless. It has often struck the writer that the collection of facts relating to the surface effects of working coal under varying conditions, and by different methods, would prove useful to the mining profession, and he ventures to submit a short account of the result of working coal, the getting of which affected the embankment of a reservoir. The mine in working lay at a depth of about 66 yards below the surface, immediately under the embankment. The thickness was about 4 feet, the roof being tender and the floor very hard.

The outcrop of the coal measures, which dip at the rate of 1 in 3, is covered with drift, and the nearest sections obtainable were at the points marked A and B on the plan. The section at A was:—

	Yds.	ft.	in.
Clay and Sand	2	0	0
White Sand (wet)	6	2	0
Marl	0	2	6
Gravel and Boulders	0	2	0
Marl	4	2	0
Blue Metal	1	2	0

and that at B:—

Soil	1	1	0
Sand	0	0	6
Marl	7	1	0
Sand (dry)	0	2	0

	Yds.	ft.	in.
Marl	1	0	0
Sand (wet)	3	1	0
Marl	7	2	8
Blue Metal.....	2	2	0

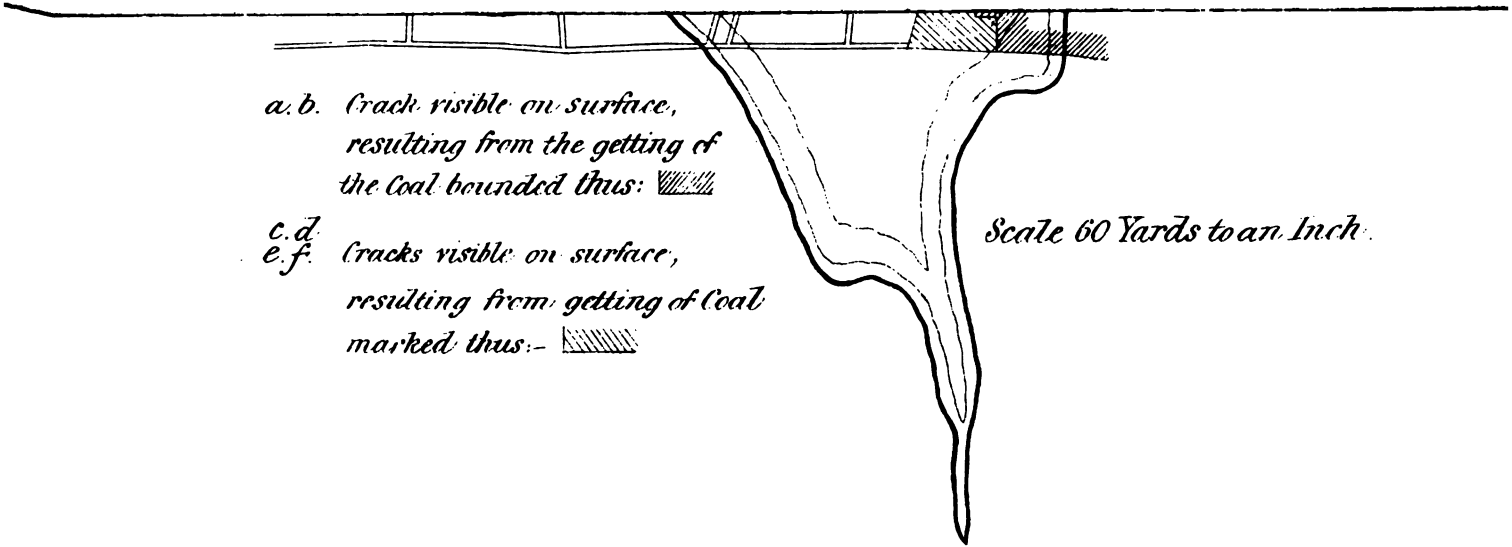
In each case the metals dip regularly. On the plan are marked the breaks of surface caused by the coal-getting, and also the extent of the workings causing such breakage. As the workings approached near enough to affect the bottom of the reservoir, which was kept full of water, it of course became impossible to observe directly the effects of the coal-getting. The first noticeable effect was the lowering of the bank at C, which took place very gradually, probably owing to the bank not being any great height at that point. In about nine months it had subsided about 18 in., and the bye-wash at D was nearly level with the surface of the water. A high wind blowing towards C rose one night, the water poured over the top of the bank, and a temporary bye-wash had to be cut at that end. The permanent bye-wash at D had to be lowered, as it was found that the opposite bank had sunk about 21 inches. At this time a small crack appeared in the embankment at E, and extended both ways, stopping, however, at F, where the embankment began rapidly to diminish in height. In the direction of D it extended past the bye-wash, which was lowered by subsidence to such an extent that it again became capable of taking the overflow water. The centre of the embankment was most affected by the coal workings, as is marked on the section, where the straight line shows the original level and the dotted line the present level. The portion shaded shows the extent of the alteration in level caused by subsidence. When the crack reached the bye-wash, the inner slope and a portion of the embankment seemed to slip inwardly into the reservoir from the back side of the

puddle trench, and the outer slope, as far as could be seen, settled against the subsided section within six months. The cross section shows the present state of the embankment, which has not visibly altered for about two years. The embankment is known to be raised on loamy sand, and the puddle trench penetrated some 5 or 6 feet into that sand, the precise thickness of the bed at that spot being unknown. To the writer this fact seems to account in some measure for the comparatively gradual subsidence of the embankment, as the foundation on which it was resting would be in a semi-plastic condition, and the weight resting thereon would have a tendency to fill or choke up such fissures as reached the original ground level. The thickness of the sand seems to be greatest in the valley bottom, across which the embankment is raised. The well-defined breaks which are marked on the plan are on the crest of a hill, all drainage from which flows into the brook course in the valley. The breaks were very clear, showing at different periods a clear ledge of 6 inches in depth. The lowering of the surface on the crest of the hill varied between 18 and 24 inches. The lowering on the comparatively flat top of the hill was not nearly so much. The strata would probably be drained to the level of the brook course in great measure, if not wholly, while the strata below that level would hold water. It seems, therefore, that when a heavy weight is based upon semi-plastic strata, that weight in some measure helps to neutralise the damage caused by mining operations affecting the surface. Sand and marl are generally found alternating, but if the sand were alone, and lying on comparatively hard strata, the effect might be different. It is well known that tapping and letting off a sand causes much damage to the surface, but in this case there was no probability or possibility of that being done, except it was let into the pit, which from the known nature of the underlying strata was

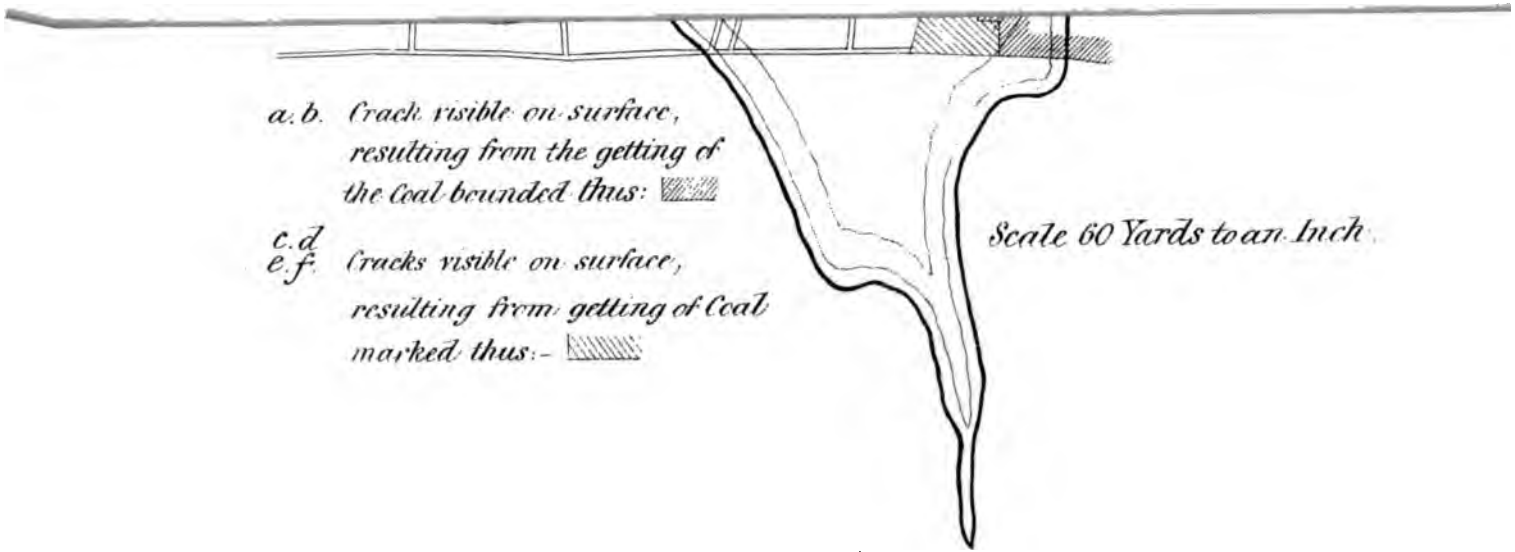
considered almost impossible. Water seems to play an important part in supporting superincumbent strata. A case thereanent came under the writer's notice a few years ago. A colliery at which operations had been suspended for many years, owing to a large influx of water, was re-opened. During the period of suspension a considerable number of buildings had been erected upon land which was to a considerable extent undermined. Before the water was entirely cleared, the surface was affected in several cases, the cause evidently being the withdrawal of the water. The amount of coal required to be left for surface support, and the position thereof, is a very difficult question to solve, as the conditions of working, and the nature and inclination of the strata and surface vary so exceedingly. An accessible record of actual facts must be of some use in the matter, as the local knowledge of individuals is often difficult to obtain.

It was resolved that the discussion upon the paper should be taken at a future meeting.

Trans. Man. Geo. Soc. Part XX. Vol XIV.


a. b. Crack visible on surface, resulting from the getting of the Coal bounded thus:
c. d.
e. f. Cracks visible on surface, resulting from getting of Coal marked thus:-
Scale 60 Yards to an Inch.

Trans. Man. Geo. Soc. Part XX. Vol XIV.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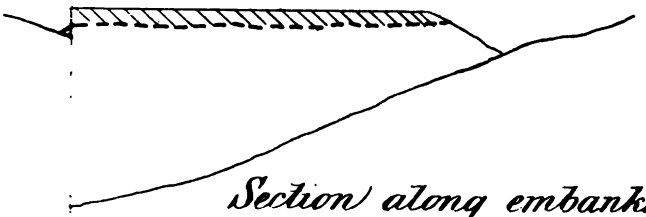
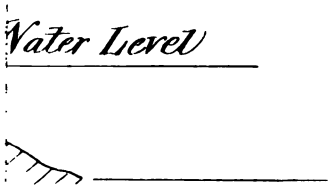
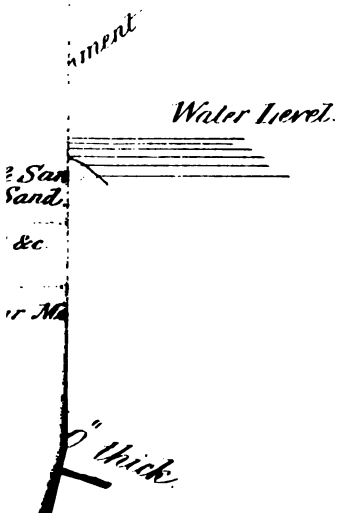
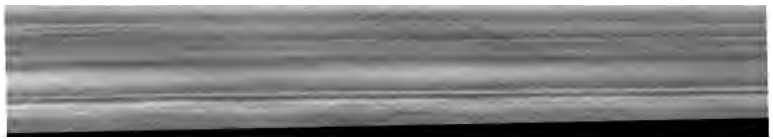


Section along embankment

Scales — Horizontal 50 feet to an Inch.
Vertical 30 feet to an Inch







ERRATA.

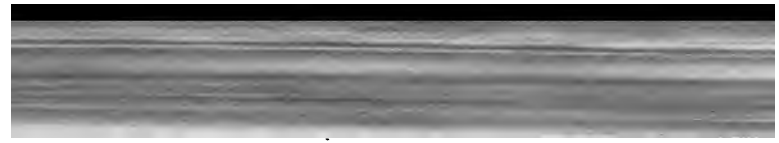
APPENDIX I.

Hardness of	Parts in 100,000. Minimum.	Maximum.	Average.
Rain Water	0 to 10		0·62
Water from Igneous Rocks	0·8 „	5·9	2·1
From Lower Greensand.....	3·6 „	44·3	27·3
„ Metamorphic, Cambrian, Silurian, and Devonian	0·4 „	6·9	2·5
„ Millstone Grit	0·9 „	9·0	4·7
„ Lower London Tertiary and Bagshots.....	1·8 „	5·6	3·8
„ New Red Sandstone (t. h.)	0 „	19·8	7·4
„ Coal Measures	9·9 „	75·0	35·7
„ „ „ (per hd.)..	1·2 „	48·5	20·6
„ Mountain Limestone ..	11·0 „	48·5	19·8
„ „ „ (per hd.)	3·3 „	12·9	8·9
„ Oolites	16·9 „	38·0	24·4
„ „ (per hd.)	3·5 „	13·5	6·2
„ Chalk	19·1 „	50·0	27·7
„ „ (per hd.)	2·7 „	13·8	6·5
„ Lias	10·3 „	50·0	30·1
„ „ (per hd.).....	1·7 „	14·7	8·2
„ Magnesian Limestone ..	14·7 „	67·3	43·8
„ „ „ (per hd.)	13·9 „	40·8	26·9

Analyses given by the Rivers Pollution Commission, Vol. VI. To transfer these to Clark's scale, multiply by 7, and move decimal point one place to the left.

The rainfalls between Manchester and Sheffield were given by Mr. Bateman, in evidence before the Royal Rivers Commission. That of Newton should be 35 not 65 inches, as printed.

C. E. Der.



TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XXI. VOL. XIV. SESSION 1877-8.

At the ORDINARY MONTHLY MEETING of the Members of the Society, held on Tuesday, the 28th May, 1878, in the Literary and Philosophical Society Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., President, in the Chair.

REMARKS ON SOME FENESTELLIDAE.

BY ARTHUR WM. WATERS, F.G.S.

When I first met with Actinosoma, which is clearly one of the Fenestellidae, the stellate nature of the aperture seemed so different from any Bryozoa structure that I thought it must belong to some other group.* Although I do not now hold so definite an opinion, it may be well to see if there is sufficient evidence to justify the Fenestellidae being placed with the Bryozoa. With this object I examined the aperture of some Fenestellidae in my possession through the kindness of Dr. G. D. Brown. In a Polypora, which is common in the Carboniferous shales of Lanarkshire, the aperture is nearly closed by a thin

* Prof. and Mr. Young have expressed a doubt as to whether these fossils should be classified as Bryozoa.

calcareous covering, with a very minute opening in the centre, as seen in Fig. 5. This has been mentioned by Dr. Young and Mr. Young in the Geological Magazine, Vol. I., new series, 1874. A similar structure obtains in a species which is almost the same as Fig. 3, and is something like Fenestella carinata; but in the species figured as No. 3, I always found the aperture open.

In Glanconome, Fig. 6, the aperture is open, and as this and Fig. 3 have the aperture so well preserved, it allows us to conclude that no calcareous portion has been removed.

It will be seen that the opening in the centre of the diaphragm is exceedingly minute, and may well lead us to ask whether this was the cell of a Bryozoan polypide or some other animal. It should not be forgotten that the cells of Fenestellidae are all very small for Bryozoa.

The other points which the figures are meant to represent are, that there are fine tubes passing through the shell, though not as distinct as in Fig. 4, which is a transparent section of Polypora, Fig. 5.

These tubes cause the ornamentation which is seen on many specimens, as for instance in Fig. 2, which represents the reverse of an Actinosma. As is well known, there are tubes passing through the shell of Bryozoa.

I wish to call particular attention to Fig. 7, which is from a section I made of a species of Fenestellidae, which may be carinata, where in each cell there are two denticles, which I am unable to explain. If anything of the kind is found in different positions and in other species, some light may be thrown on its signification.

The Fenestellidae were at one time thought to belong to the Reteporidae, on account of their growing in a reticulate manner, but this mode of growth is not confined to Reteporidae, and there was no sufficient reason for such a position being assigned.

In the sub-order, Cheilostomata, to which Retepora belongs, the cells are closed by a lid or operculum, and the opening is, I think, never central; on the other hand, the Cyclostomata consist of tubes in which are the polypides, and there seems as much or more resemblance with this order. In the Cyclostomata the cells are often after a time closed by a diaphragm, in most cases some little distance down the tube; but the calcareous covering in Fig. 5 is so constant in all well preserved specimens that have come under my notice, that I am doubtful if a comparison can be made with this, though certainly, from the observation of Prof. and Mr. Young, it would appear that this cover was deposited after the shell.

In Mesenteripora meandrina, a form fossil in the Pliocene, and which now lives in the Mediterranean, the tubes project and frequently are nearly closed at the end with a plate, which has a long minute tubular projection in the centre. This tube is sometimes two or three times the length of the diameter of the zooecial tube. This cover has been thought to be homologous with the diaphragm, which closes the tubes of many Cyclostomata; and this view must be accepted, though in some specimens dredged at Naples, where the zooecial tubes are not abraded, this fine tube is always present; and I am led to believe that the study of the polypide of this species may throw some light on the structure.

I should further like to point out that the ridge, or keel, seen in Fig. 1, 3, 6, from the limited number examined, seems characteristic of the Fenestellidae. Although nothing of the kind is shown in the small fragment from the growing end of Polypora, Fig. 5, there is usually a protuberance in about the length of every two cells, so that normally there should be two in the portion drawn.

On the keel mentioned there are protuberances as in

Fig. 1, 3, 6, 8, but what signification these have is not known; but clearly in classification the greatest importance should be attached to their number and position. These may have had spines or organs analogous to vibraculae, or even zooids, but that must at present remain a subject for further research.

From the slight acquaintance I have with the subject and its literature, it seems that the classification of the Fenestellidae requires considerable revision, as more attention should be given to minute characters, and not so much to the number of cells between the dissepiments.

As I have no intention at present, at any rate, of diverging from the study of younger deposits to make a detail examination of this group, I point out the above in the hope of inducing someone more competent, to examine and see if we are justified in retaining the Fenestellidae among the Bryozoa; and to make my meaning clearer, have appended drawings, but feel that an excuse is necessary for the shortcomings of this first attempt at lithography, and hope if again I have occasion to illustrate any remarks to the Society that they may be more worthy of a place in the Proceedings.

EXPLANATION OF FIGURES.

1. Actinosoma.
2. Reverse of Actinosoma (not the same species as Fig. 1).
3. Fenestella.
4. Transverse section of Polypora.
5. Polypera (young branch, in the fully grown, the zoocia are more numerous).
6. Glanconome, probably flexicarinata, Dr. J. Young and Mr. J. Young.
7. Transparent section Fenestella, perhaps carinata. This section is horizontal, D is one of the dissepiments and O is an Osculum.
8. Section of same Fenestella at right angles to the direction of growth, cutting through two branchlets joined by a dissepiment.
9. Pore of Actinosoma, magnified 200 times, all the rest are magnified 85 times, as is also the scale attached.

BRYOZOA (POLYZOA), FROM THE PLIOCENE OF BRUCCOLI (SICILY).*

By Arthur Wm. Waters, F.G.S.

In Sicily there are deposits consisting of broken shells and a large number of Bryozoa, having the general appearance of the English Crag. In the parts of Sicily which I visited this "Crag" is much harder than the underlying beds of the Messinian formation, so that as soon as denudation has cut through this harder rock it rapidly cuts deep valleys in the soft marl. The consequence is that these nearly horizontal beds are seen as flat tops to the hills which rise to many hundred feet, in some places much over a thousand feet, above the sea level. And as nearly all the villages are built on these "Crag" flats it will readily be imagined that this is a very characteristic feature, as the landscape shows isolated villages perched as mountain strongholds all over the country, and the pedestrian has to pay for this by great delay, for in passing from one village to another, although the distance may be only a quarter of a mile, it often happens that the ascent and descent will occupy some hours.

I, however, believe, from the section furnished to me by Dr. Fuchs, that those now to be described are older. They were collected by Dr. Theodore Fuchs, of Vienna, who lent them to me, and I have for a long time been anxious to complete a description of them, but circumstances have hindered, but now take the earliest opportunity in order that I may return them to the owner, and show him that I do not intend to break the eighth commandment, and I gladly

* Bruccoli, or Brucoli, is near Lentini, which is between Catania and Syracuse.

avail myself of the occasion not only to thank him for lending them, but also for not complaining of the unavoidable delay.

The following section, by Dr. Fuchs, will explain the position of the beds in descending order :—

(*a.*) Upper pliocene sand, gravels, and limestone, with Cerithium vulgatum, C. scabrum, Murex trunculus, Rissoa, Turbo, Trochus, Monodonta, Ostrea, &c.

(*b.*) Yellow sands without fossils.

(*c.*) Blue marl with Buccinum semistriatum, Natica helicina, Dentalium elephantinum, Chenopus pes pelicani, Nucula, &c.

(*d.*) Bryozoa beds with corals, Brachiopoda, Pecten opercularis, &c.

From the works of Sequenza it seems that the Bryozoa described by Manzoni, from Sicily and Calabria, are also lower pliocene.

I must repeat the excuse of early efforts for the drawings, which I regret are not better finished.

Cheilostomata.

1. Salicornaria farciminoides, Ell and Sol.

As this species is most widely distributed, both in the living and fossil state, it has been examined by many observers, and consequently possesses a long list of synonyms. These have been tabulated by Reuss, in his Foss. Bryoz. des Oest-Ung. Miocäns, and it is not necessary to repeat it. This species is, however, considered to be the same as S. sinuosa (Hassall), and among the fossil forms the same as Vincularia and Cellaria marginata (of Goldfuss and Reuss). It occurs now in the seas of Norway, Spitzbergen, &c., to the Mediterranean, where it is very common. It is also found in the North American seas, Madeira, and South Africa (in Algoa Bay).

Fossil it has been found in the Bartonian (Upper Eocene) of the Vicentine (North Italy), in the Oligocän of North

Germany, in the Miocene of Austria and Hungary, in the Pliocene Coralline Crag of England; and in the Pliocene of Italy it seems to be so generally distributed that there is no object in repeating a list of some twenty or thirty localities; but although I found this common in beds of this age in Sicily and Calabria, there was only one small fragment in the collection submitted by Dr. Fuchs. This species is found at Naples from 10-20 fathoms and deeper, but is there smaller than the Sicilian fossils.

2. Membranipora bidens, Hag. Die Bryozoen der Maastrichter Kreidebildung, 1851. Syn; Cellepora hippocrepis, Rss. Foss. Polyp. des Wiener Tertiärbeckens. Haidinger's Abh. II. s. 1, 1847.

The specimen from Bruccoli, with high powers shows fine sulcation, or granulation of the walls. The "teeth" are in most cells scarcely distinguishable, but in others are more clearly seen.

I am inclined to think that Membranipora Rosselii, Aud. as figured by Manzoni in his 4ª Contribuzione, is really bidens, or perhaps a variety, as from the large size of the aperture it entirely differs from the Rosselii which I collected at Naples. We may, however, thus see a connection between these two, which are perhaps related to the group of which calpensis may be taken as the type.

This has been found fossil in the upper chalk at Maestricht and Rügen, in the Helvetian (upper Miocene) of Austria and Hungary, in the English Crag, in the Pliocene of Castrocaro (Italy), and is now living in the Arctic Seas of Europe.

2A. Membranipora Lacroixii, Savigny.

The Membranipora, from Bruccoli, which I believe to be M. Lacroixii, has the zooecia much more separated than in those figured by Busk, so that there is a distinct space between the cells, which are regularly oval. The walls

bordering the cells are distinctly ornamented with radial lines.

Loc. Fossil in the Miocene of Austria and Hungary; Pliocene-Voltura; and a closely allied form of Membranipora Savartii, occurs in the English Crag. This is now found common in the European seas, Florida, and according to Busk, doubtfully in Australia.

A variety, diadema, Rss., has been described from Immendorf.

Fig. 3.

3. Membranipora andegavensis, Mich.
var, papyracea.

As the shape of the zooecia correspond more with papyracea of Rss than with his gracilis, it will be best to call this only a variety. As it is impossible, from the figure and description of Goldfuss, to decide if gracilis is the same as andegavensis, I have not followed Reuss in using the name given by Goldfuss. This has a pore just behind the mouth on each side, and in most cells there is another smaller pore behind this, as shown in the figure. The surface is decidedly concave, with perforations, the space between the perforations is granular, as seen in the enlarged portion of the surface; the marginal ridges are sulcate or granular. At each side of the mouth in most cells the marginal ridge thickens. This is unfortunately not shown in the drawing.

4. Membranipora Angulosa, Rss.

This is a species which has had a wide range in tertiary times.

Loc. Bartonian (Upper Eocene)—Oberburg (Styria), Val di Lonte. Miocene—Austria, Hungary, Moravia, Turin, Dego. Pliocene—Castrocaro, Castellarquato, Pisa, Arno, Sicily. Living—Mediterranean.

In living specimens the cell is seen to be covered with a thick membrane obscuring the calcareous wall, and this extends over the large aperture, but near the distal end of

the aperture is the small movable lip through which the polypide protrudes.

There are probably a number of species which should be reduced to synonyms of this form, and it should be noticed that in the chalk there are several so-called Escharae described, which have cells like the above, but which would now be Biflustra.

The large avicularian cells are the same in the Bruccoli fragments and in those dredged in the Bay of Naples as those well drawn by Manzoni in his description of Castrocaro and in other places.

5. Lepralia ciliata, Pall.

Cellepora crenilabris, Rss. foss. Polyp. Wien. Beck. tab. x f. 22, p. 88.

Loc. Miocene—Austria and Hungary. Pliocene—Crag, Reggio, Castrocaro, Castelarquato, Canitello (Calabria), Parlascio (Pisa), Castelviscardo, Darsena (Leghorn). Living —Northern seas, British coasts, France (Joliet), America, Adriatic (Heller). At Naples it is common. I dredged it in 40 fathoms, but received specimens often from shallower water.

Fig. 2.

6. Lepralia Morrisiana, Busk.

The oral aperture is smaller than is shown in the figures of Reuss and Manzoni, but otherwise there seems no difference. Although this was abundant at Bruccoli, there are only two or three ovicells to be seen on the various fragments.

Loc. Pliocene—Cor. Crag, Leghorn (Manzoni's 2ª Cont.). L. pleuropora and inamoena, Rss., are apparently closely allied to this species.

Fig. 22.

7. Lepralia vulgaris Moll.

Busk. Quart. Journ. Micro. Sc., vol. vi., 1858, p. 127, tab. xviii., fig. 3.

Cellepora otophora, Rss. Foss. polyp. d. Wien. Tertiärbeckens, p. 90, tab. 11, fig. 1.

Lepralia otophora, Rss. Foss. Bry. des Oest-Ung Miocäns p. 164, tab. 8, fig. 5.

(?) Lepralia tumida, Manz. Briozoi di Castrocaro, p. 25, tab. iii., fig. 33.

Lepralia intermedia, Rss. Oest-Ung Mioc. p. 160, tab. 8, fig. 11.

I think there cannot be any doubt that this is the same species as Reuss figures from the Miocene as otophora. The figure given by Manzoni of Lepralia tumida seems to correspond better with Reuss' otophora than does fig. 30 from Castrocaro. This is closely allied to Heller's Lepralia Botterii, found at Lesina, and may be the same, but I am unacquainted with this species.

At Naples the vulgaris does not seem to be common, as I only found it upon re-examining some material brought home.

In the Bruccoli specimens the surface is finely granular, the vibracula turn slightly inwards, and in many cases show the hinge; there is a distinct sinus in most cells, and the upper part of the aperture is surrounded by spines.

In the recent species, the rostrum is very variable, in some cases being almost invisible, in others long and prominent.

Loc. Miocene—Austria and Hungary, Lapugy (Siebenbürgen), Modena (Italy). Oligocän—varieties at Crefeld and Sollingen. Pliocene—Castrocaro. Living—Madeira, Mediterranean.

It is possible that L. Morrisiana is a variety.

8. Lepralia coccinea, Abild.

Syn. L. Ballii, John. Hist. Brit. Zooph., 2nd Ed. tab. lvi. fig. 5.

There were several specimens of this most beautiful Bryozoa in the material collected by Dr T Fuchs.

In some specimens there are nearly always two avicularia, in another there is usually one on each side, while one fragment shows that while some cells have avicularia, a large number have none. When the aperture is viewed from above there is often visible a denticle, as seen in the Eschara figured as No. 4.

Loc. Crosaro, Val di Lonte, Miocene of Eisenstadt (Hungary). Pliocene—Castrocaro Canitello, &c., Sicily.

Living—Northern seas, Britain, France, Mediterranean.

At Naples I received this from quite shallow water to the deeper water of 40-50 fathoms.

9. Lepralia innominata, Couch.

Loc. Pliocene—Castrocaro (rare), Crag. Quaternary—Reggio (A. W.)

Living—Mediterranean, Florida, Roscoff (Joliet L'histoire nat. des Bryozoaires Lacaze-Duthiers, Arch. 1877), British seas.

This I dredged at Naples at depths from six fathoms to considerable depths, where Gorgonia is plentiful.

10. Lepralia arrecta, Rss.

Cellepora arrecta, Rss. Foss. Polyp. d. Wiener Tertiärbeckens, p. 81, tab. ix., fig. 23.

Lepralia arrecta, Rss. Die Bryozoen des Oest-Ung Miocäns, p. 164, tab. ii., fig. 11.

The aperture of the zooecia, in the pieces I have from Bruccoli, is variable, and I believe shows that L. disjuncta, Manzoni. is the same species. This last is described by Manzoni from Castrocaro and Castellarquato, and I have it also from Reggio.

Loc. Miocene—Eisenstadt (Hungary).

11. Lepralia ansata, John. var. porosa, Rss.

Syn. Busk—Lepralia unicornis. Crag Polyzoa.

With this group it is very difficult to know which name to use, as the ansata, unicornis, spinifera, can scarcely be

determined by the description and figures given by Johnston. It is necessary to take one of this group and make these nearly allied varieties, as is done by Reuss, who makes unicornis and spinifera into var porosa. Heller makes spinifera the type of four varieties, but retains ansata. As pointed out by Heller, the ansata of Johnston may be coccinea, and not what we now understand by ansata. Smitt has called spinifera and ansata varieties of his Mollia vulgaris.

Loc Oberoligocene of Doburg. Miocene of Austria and Hungary. Crag (as unicornis). Living Mediterranean. Naples.

12. Lepralia auriculata, Hass.

One specimen from Bruccoli entirely corresponds with fig 4 of Plate lxxxix. of Busk's catalogue; and there is also one which I think must be placed with auriculata, though it does not quite correspond with any of the figures of this specimen, or with any I have from Naples, and I therefore describe it as a variety.

Fig. 5.

13. Lepralia auriculata, var. Leontiniensis.*

Encrusting Pecten, eight or nine layers superimposed, cells irregularly rhomboidal, ovate, elongate, immersed, surface covered with distinctly raised warts punctured in the centre, mouth obicular with a sinus below, avicularia deeply immersed, zooecia separated by a wide distinct line.

The avicularia are sometimes absent, and when present are very variable, in most cases having the appearance merely of an imperforate portion of the shell. This is best seen in the lower cell, marked *(a)*, which represents the general character of the majority of cells. When sections are prepared the shell is seen to consist of two layers connected by short tubes. A similar structure has been pointed out to me by Mr. Chas. Stewart, F.L.S., M.A., in a recent

* From Lentini, the Leontinoi of the Greeks.

specimen from the Mauritius, which I hope he will shortly describe.

L. auriculata is found in the northern seas to the Mediterranean.

Fig. 6.

14. Lepralia cupulata, Manzoni.

Manzoni, Bryozoi foss. Ital., 3a contrib., p. 13, tab. iv., fig. 21, Sitzb. d. k. Akad. d. Wiss Wien LIX.-LXI 1869, 1870.

There are two or three small Trochi, probably Montacuti, covered with the Lepralia, which I believe must be the same as that figured by Manzoni. Except on one the Bryozoa are too much rolled to see the form clearly. The cells are arranged quincuncially, rather regularly except where the uneven surface causes irregularity, ovate rhombic, surface but slightly raised perforate, aperture elongate, contracted in the middle, below and to the side of the aperture on each side a distinct callosity; margin of cells very distinct.

In the Bay of Naples the smaller species of Trochus are frequently covered with this Lepralia. The recent form may be L. Kirchenpaueri, Heller; and is closely allied to L. lata of Busk but is not quite the same.

The shell of Trochus so soon becomes the habitation of hermit crabs that they are rolled about, and, in consequence, the Bryozoa incrusting them are much damaged.

Loc. Miocene—Hills of Turin, Sassuolo; Pliocene—Val d'Era. Living—Naples.

15. Lepralia Bowerbankia, Busk.

Busk: Crag Polyzoa, p. 50, tab. vii., fig. 4.

Manzoni: Bry. foss. Ital. 1ª contrib., p. 3, tab. i., fig. 5.

The specimen is not very well preserved, but I think sufficiently well to leave no doubt of its determination. The aperture is orbicular, with a sinus below, prominent umbo, surface coarsely punctate: the cells are more elongate than those figured by Manzoni, but are placed in very regular rows quincuncially.

Loc. Coral. Crag, Castellarquato (North Italy.)

Fig. 7.

16. Lepralia resupinata, Manzoni. I Briozoi del Plioc. antic. di Castrocaro, p. 20, tab. ii., fig. 26.

The specimen from Bruccoli is growing on a piece of Cellepora, and fairly closely resembles that from Castrocaro. It will be seen from the figure that the avicularia are sometimes very large, in other cases quite small; when small, there are usually two, and these are situated near the aperture of the cell. There are four oral spines. The situation of the ovicell behind the zooecium is characteristic.

Loc. Pliocene, Castrocaro.

17. Lepralia scripta, Rss.

Syn. L. megacephala, Rss. Poly d. Wiener Tertiärbeckens, p. 82, tab. ix., fig. 28.

This is beautifully preserved at Bruccoli, but as it has been very well figured by Manzoni as a Mediterranean species in his Supplemento alla Fauna dei Bry. Medit. Sitzb Akad Wirsench. Wien. lxiii., 1871, it is not necessary to give a figure now, although the zooecia are slightly more elongate.

Loc. Miocene—Hill of Turin, Eisendstadt (Hungary). Pliocene—Piacenza, Tuscany, and Sicily. Living—Mediterranean. From the Bay of Naples I have some specimens.

18. Lepralia Pallasiana, Moll.

Probably several fossil species are Pallasiana which have received other names.

Loc. Pliocene—C. Crag, Sicily. Living—British coasts and Mediterranean.

19. Cellepora coronopus, S. Wood.

There is no genus which causes so much difficulty and uncertainty in the determination as this, and there may be other species among the numerous pieces collected at Bruccoli, but I am not able to determine at present any others

than the three enumerated. As Cellepora varies so much in different stages, it is doubtful whether several of the existing species should not be united.

Loc. Pliocene—C. Crag, Ficarazzi. Living—Naples.

Fig. 20-21.

20. Cellepora tubigera, Busk.

Fig. 20 shows a portion when the cells are decumbent, and in such cases there are no tubular process, while in the same piece where the cells are erect there ure usually some processes. Fig. 21 will show the shape of the ends of the cell when erect, but unfortunately this figure is a failure and does not show the shape of the cells. It seems to me probable that C. retusa, Manz. is only a variety.

Loc. Pliocene—Pezzo, Canitello, Carrubare (all Calabria), C. Crag. Living—British and French coasts, and Mediterranean.

21. Cellepora ramulosa, Linn.

Loc. Pliocene—C. Crag, Pezzo, Canitello (Calabria), Castrocaro. Living—Scandinavia, Britain, France, Mediterranean. This I dredged at Naples, in 40 fathoms.

22. Hippothoa catenularia, Jameson.

Busk—Cat. Marine Polyzoa, p. 29, tab. xviii., figs. 1 & 2. Manzoni—Bry. fossili Ital., 4ª contrib., p. 6, tab. i., fig. 4.

Loc. Pliocene — Reggio (Calabria), Canitello, Pezzo. Living—Seas of Europe, in Adriatic at Lesina, Lissa, common (Heller.) At Naples I found it several times. Devonshire, common in deep water; found at 60 fathoms on Pinna by Hincks.

Fig. 9.

23. Eschara lunaris nov. sp.

This Eschara I have been unable to correlate with any described species; but as it occurs in the Mediterranean, and the Pliocene of Sicily at various places, it must have been often seen, if not described.

I believe that it is the same as Porina labiata (Roemer),

from the oberoligocän of Lattdorf, although the lip is not as prominent in those from Naples. It is only in the terminal or younger cells that the aperture projects, so that if the above supposition is correct, Roemer's labiata would be taken from a young cell.

There also seems very good reason for believing that Eschara columnaris, Manzoni (Bryozoi di Castrocaro, tab. v., 65) is the same, but as that is evidently taken from a badly-preserved fragment it is somewhat uncertain. The cells near the base have just the form and shape drawn by Manzoni, and the avicularia are often obliterated, though in a piece as large as that figured I should expect some cells to show a trace of its existence.

Stem cylindrical, dividing dichotomously, cells at the growing extremity ovate, near the base hexagonal, mouth orbicular, young cells projecting, old cells deeply immersed, four oral spines on the upper margin of the aperture, semi-lunar pore below the mouth, avicularium on one side of the cell, with extremely long mandible (often the length of nearly two cells), surface coarsely punctured, ovicell finely punctured. The cells in Figure 7 are in a medium stage, being neither the recently-formed or obliterated cells. The figure showing the natural size is from a recent specimen dredged at Naples. The description is also taken from recent specimens.

Loc. Pliocene—Rametto (Sicily), San Domenica (near Rametto), Parere (Calabria), in my collection.

Living—Naples, 40 fathoms in the Secca, &c.

The form of the zooecia is much the same as in Eschara flabellaris (Busk) from Algoa Bay, but that is not cylindrical.

The name is given from the semi-lunar pore, which occurs frequently in Lepralia, but there are few Escharæ with it. This would be called Porellina ciliata by Smitt.

24. Eschara cervicornis, Ell and Sol.

Several pieces of this Eschara were among those collected at Bruccoli. Manzoni is doubtful of the identity of a frag-

ment from Castrocaro, but thinks it may be Eschara undulata Rss., in which I think he may very likely be correct.

Through the kindness of Prof. Guiscardi I was enabled to examine a few Bryozoa from the Pliocene of Sicily, which were probably collected by the elder Costa; and there were some fragments of cervicornis from Canitello (Sicily). I found it abundant in the Pliocene beds in Sicily and Calabria, already mentioned.

Loc. If as undulata, in the Miocene of Austria and Hungary. Pliocene—Sicily and Calabria, abundant; living, Mediterranean, very abundant in a depth of 30 fathoms and deeper; Roscoff (Joilet), 30-40 metres, British, Start Point, &c.

Fig. 8.

25. Eschara biaperta, Mich.

forma Eschariformis nov.

As Lepralia.

Michelin—Icon. Zooph, p. 330, pl. lxxix., fig. 3.

Busk—Crag Polyzoa, p. 47, tab. vii., fig. 5.

Manzoni—Briozoi di Castrocaro, p. 21, tab. ii., fig. 28.

Polzoarium erect foliaceous, zooecia quincuncial and serial, surface smooth, margin of cell indistinct, orifice obicular sinus seldom visible, an avicularian or vibracular process on one side of the top of the cell, sometimes a mamelon on the other side.

The irregular surface of the zooarium scarcely shows the outline of the zooecia, but their position can always be made out by the conspicuous aperture and process. In the specimen from Bruccoli the processes on one side of the zooarium are always on the right, on the other on the left. I suppose that this line indicates the centre of the colony, and have, in consequence, filled in with a dotted line what I assume may have been the width of the branch.

This form of cell has been found as Lepralia in the Crag, in the miocene of Douè (France); and Manzoni figures L. biaperta from the pliocene of Castrocaro (N. Italy), with two vibracular processes and an avicularium on the side of the cell.

This is a case which is frequent of finding Lepralia and Eschara with similar cells, and I have thought it best to signify its relation to Lepralia biaperta and its growing as an Eschara by retaining Michelin's name, and showing its form by calling it variety Eschariformis.

Fig. 4.

26. Eschara Pertusa, M. Ed.

The figure 4 is most unsuccessfully drawn, but I think it will explain the point to which attention should be called. When the broken ovicells are examined there is found to be a calcareous film covering the interior, but in some cases this is broken away, revealing a deep furrow just above the oral aperture, and at the bottom of this furrow are two or three distinct perforations. In some cells a denticle is visible. Four lateral and two distal rosettenplatte.

Loc. Miocene—Douè. Pliocene—Crag, and in my collection from Reggio, Gerace (Calabria), Rametto (Messina).

27. Eschara Foliacea Lam.

var Fascialis.

Although foliacea and fascialis are considered synonyms, it may be useful to retain the distinction as to the form of growth, and therefore, instead of following Heller (Die Bryozoen des Adriatischen Meeres. Sitzb. Akad. Wien., 1867), and calling them distinct species, the smaller size of the foliations is indicated as above. This has in the distal wall two "rosettenplatte," and four in the lateral wall.

Loc. Pliocene—Castrocaro, Ficarazzi, Leghorn, Pesso, Canitello (Manzoni), and a specimen in the Naples museum collected probably by Costa from Amati is this species.

Living—Brit. (common), France, Mediterranean (common).

Fig. 1.

28. Biflustra rynchota, nov. sp.

Polyzoarium foliaceous, two layers of cells opening in opposite directions, cells quincunxcially arranged, margin thickened at the proximal end of the cell, no thickened

margin at the distal end, aperture large, suborbicular, straight below, or subquadrilateral, sometimes nearly as large as the cell, avicularia on the front of the cell below, opening of the avicularia elongate narrow.

The cells of this species seem to have the characters of Membranipora rynchota as figured by Busk, and is another of those cases of getting similar zooecia in erect and the encrusting forms.

The avicularia in most cells much more nearly resembles those of rynchota in the Crag Polyzoa than is shown in Fig. 1. This is related to the recent Membranipora minax (Busk) and Pouilletii (Aud.)

29. Retepora cellulosa, Linn.

This species has a wide range in space and time, and is now common in the Mediterranean and many other seas.

Loc. Miocene—Eisenstadt (Hungary), Astrupp, Superga, Angers, Douè, Vihier, St. Laurent des Mortiers, Angles, Vedennes, L'Etang de Thau (Herault). Pliocene—Pezzo, Canitello (Sicily), Parere (Calabria), (A.W.), Messina, (A.W.), C. Crag. Living—In all the northern seas, Britain, coast of France, Mediterranean, N. America, Cape Horn, Australia. Found at from 20 fathoms to deep water.

30. Myriozoon truncatum, Pall.

Reuss—Vaginopora polystigma Rss. Die foss. Polyp. des Wiener, Tertiärbeckens, p. 73, tab. ix., fig. 2.

Reuss—Myriozoon punctatum Rss. Zur fauna des deutsch Oberolig, p. 50, tab. ix., fig. 2, and Bry. d. deutsch. Septarienthon, p. 190.

Manzoni—I Briozoi fossili del Mioc. d' Aust. ed Ung., pt. ii. Denk. K. Ak. d Wiss. xxxvii., 1877. p. 22, tab. xv., f. 52; tab. xvii., fig. 55.

This genus was originally placed by Reuss in the family Vincularidea, but that is clearly a mistake, though the affinities do not seem clear. It appears sometimes to have been placed with Cyclostomata, but as it has such a well developed operculum, this is somewhat strange. At Naples

it is fairly abundant at depths from about 30 fathoms. Abundant at Bruccoli.

Loc. Miocene—(as punctatum) Eisenstadt, Portzteich, and other places in Austria and Hungary. Pliocene—Castrocaro, Mt. Titano, Darsena, Parlascio, Leghorn, Amato (A.W.), Canitello (A.W.), Asti, Bonpas, Vedennes, Villeneuve-lez Avignons (Gard), Chaux de Fonds (Suisse), and generally in the Pliocene of Sicily. Living—Mediterranean common, and probably in many other localities under synonyms.

31. Cupularia Reussiana, Manzoni.

Bryozoi Pliocenici Italiani 1ª contrib. Sitz. Akad. d Wissensch. Wien, 1869, vol. lix., p. 11, tab. ii., fig. 19.

Cupularia doma, d' Orb. Smitt Floridan Bryozoa. Kongliga Svenska Vetens. Akad. Handlingar 1872, vol. ii., pt. 2, tab. iii., 81-84a.

The Bruccoli specimen is exactly the same as that figured by Manzoni, which he points out is closely related to Cupularia denticulata and Owenii, which have been found in the Miocene of Williamsburg, Crag of Suffolk, and living on the coast of Africa, Canary Isles, and Madeira.

A specimen in the Naples collection, already referred to, is marked Trocopora brutia, Costa; but I am not aware whether Costa published a description of it, which was probably collected by him, and was from the pliocene of Amato (Sicily).

This is the same species as Smitt figures as Cupularia doma, d' Orb but upon what grounds Smitt thinks this is the same as Discoflustrella doma of d'Orbigny (Pal. cret p. 561), I am unable to understand, as the figure and description of d'Orbigny are insufficient for determining any recent species.

Although the form of the zooecia agrees with the figures of Manzoni and Smitt the shape of the zooarium is more depressed, and the description of the Bruccoli specimen should be polyzoario depresso-conico, instead of hemispherico.

Loc. Castell-Arquato, Orciano, Mt. Mario, Rhodes. Living —Florida.

CYCLOSTOMATA.

32. Diastopora flabellum, Rss.

Die foss. Poly. der Wien, Tertiär, p. 51, tab. vii., fig. 9.

Manzoni—I Briozoi foss. d. Miocene d'Aust., pt. iii.; Denk. Ak. Wien, 1877; p. 14, tab. xiii., fig. 52.

Diastopora simplex, Busk (non d'Orb.), Crag Poly., p. 113, tab. xx., fig. 10.

From the specimens from Bruccoli I feel sure that flabellum and simplex are synonyms. Dr. Busk, in naming his species simplex, has apparently overlooked the fact that d'Orbigny had already given this name to another species, which he subsequently changed to Discosparsa simplex, but which would now, according to the catalogue of the Cyclostomata, be Diastopora.

Loc.: Miocene—Eisenstadt, Wildon, &c. Pliocene—Crag; Living—Naples., &c.

33. Alecto major, Landsb.

Syn. A repens, S. Wood.

Loc. Pliocene—Crag (red and coralline), Douè (?), Castrocaro. Living—Arctic seas to Mediterranean, Florida; at Naples, on Terebratula vitrea, also from other localities, as a deep water form.

34. Pustulopora proboscidea, M. Ed.

Loc. Living, Shetland seas, Mediterranean, Teneriffe, Canaries, and Madeira. (Busk's Cat., pt. iii.)

This I dredged at Naples in 30 fathoms and deeper water,

Fig. 15.

35. Pustulopora rugosa, d'Orb.

Entalophora rugosa, d'Orb; Pal. Franc.: p. 795, tab. 754. fig. 18-20.

Pustulopora rugulosa, Manz.; I Brioz foss. del Miocene d'Austria e Ungheria; parte iii., p. 11, tab. x., fig. 38; Denk. Ak. Wiss, Wien, xxxviii., 1877.

Colony composed of cylindrical branches covered with tubular projecting cells, the tubes and interspaces rugose; in old branches tubes closed at the base by a diaphragm; surface finely punctured.

I am unable to see any difference between the living, the chalk, and the miocene species as far as can be gathered from the figures and description.

It is only in well preserved specimens and with a fairly high power that the punctures in the surface can be seen, so that this character would often be wanting in fossils. The figure, natural size, is from a specimen dredged at Naples, where it is not rare, at depths from 30 fathoms downwards. I have also taken the license of adding, from a recent specimen, two tubes on the right-hand side, to show the length they attain. In the specimen from Bruccoli the ends are broken off.

Loc. Chalk, ètage 22e, as rugosa, Vendôme, Trôot (Loir et Cher), Veules (Seine Inf.) Miocene—Kostel, Lapugy, Wildon, St. Nicholai, Gartschenthal, Steinabrunn, Niederleis, Nussdorf, Grussbach.

Figs. 11, 12.

36. Discoporella mediterranea, Blain.

Busk's Cat. Marine Polyzoa, pt. iii, 1875, p. 33, tab. xxxiv, fig. 4.

Lichenophora Mediterranea, Blain, Man. d'Actin. p. 407.

In the material collected by Dr. Fuchs, from Bruccoli, there are a few fragments adnate and one stipitate, and it would seem that the mode of growth should not be used as a generic character. This view would lead to the addition of Defrancia to Discoporella, and as this is a very variable species it seems possible that Defrancia lucernaria is only a variety. The cells of the rays are in some much raised, in others the rays are less distinct.

Loc. Fossil—Astezan, Vaucluse. Pliocene—Asti (Mich.), Pruma (Calabria), my collection. Living—Naples, lami-

narian zone (A.W.); Mediterranean, on shell (H.M.S. Porcupine), (Busk).

Dr. Busk, in his catalogue, speaks of this being found in the Miocene, but he probably quotes the localities on the authority of Michelin. The Asti beds are Pliocene, and I think the other two localities are of the same age, but have no exact information.

37. Discoporella radiata, Aud.

Discosparsa patina, Heller, Die Bryoz. des. Adriat Meeres, p. 122. Verh. der k.k. zool-botan. Gesell. Wien, tom. xvii., 1867.

Loc. Living—Venice, Crivizza, Lessina, Lissa, Cuzela, South Devon; Naples, on Laurencia papillosa, abundant, and on other seaweeds.

Heller speaks of it occurring in from 20-55 fathoms, but at Naples I found it in shallower water.

Figs. 13, 14.

38. Diastopora cupula d'Orb.

Discosparsa cupula. Paleont. Franc. vol. v., p. 823, tab. 758, fig. 1-5.

Colony discoidal, cup shaped regular, thick under surface, marked with concentric lines, and rayed striae, cells immersed, free at the end, composed of three or four layers of cells.

Only one specimen found at Bruccoli, in which I am unable to find any variation from that described by d'Orbigny from the lower white chalk.

It is possible there was a thin border, as in Discoporella. There is another species, Discosparsa laminosa d'Orb., which is closely allied to this.

Loc. Turonian Angoulême.

39. Frondipora reticulata, Blain.

forma, verrucosa.

From dredgings at Naples I have specimens which exactly correspond with both F. reticulata and verrucosa, Lamx,

and also one with both characters, showing that there is only one species. Professor Smitt calls this forma, verrucosa, and to show the mode of growth I have followed him.

Loc. Mediterranean, Kamschatka, Spitzbergen.

In the Geological Museum of Naples I believe some fragments from Canitello and Amato, and marked Retepora cellulosa, are Frondipora reticulata.

Fig. 17, 18, 19.

40. Mesenteripora, sp.

On a piece of Myriozoon there is a growth like Diastopora, which rises into the foliaceous form, as seen in fig. 19. The surface is decidedly rugose, whereas in Mesenteripora meandrina, although there is a tendency to rugosity, none of my specimens from Naples could be called so, and some are quite smooth. The cells are mostly immersed, with free terminations. As there is only this one small piece it would not be safe to say if this is meandrina or a new species.

41. Hornera frondiculata, Lam.

M. Edwards—Hornera affinis, M. Ed. Ann des Sc. Nat. 2e ser., vol. ix.

Michelin—H. Andegavensis, Icon. Zooph. 318, lxxvi., fig. 8.

Loc. Pliocene—Sceaux, Douè, Crag, Sicily, Castrocaro, Ficarazzi (Sicily), Pruma and Gerace (A.W.) Living—Adriatic, on Nullipores and Corals, at considerable depths. (Heller). Dredged at Naples in the deeper dredgings.

Fig. 16.

This seems the same as Manzoni (Briozoi di Castrocaro) has figured as Aetea sica, but I do not see from his figure why he does not call it Alecto, and believe it is the same which usually grows with more cells along the line of growth, and which he figures as Alecto repens.

Nearly all of those which are not put down as existing at the present time are represented by species very closely allied, and the number of living will undoubtedly be largely

increased by further collection of Bryozoa and by a reduction of the synonyms.

There are four species which I am unable to distinguish from those figured as fossil in the chalk: 2 are Upper Eocene, 15 Miocene; 30 have been found in Pliocene deposits; 30 are now known living, all of which I collected at Naples.

It will have been seen that the greater number of this list are those which inhabit the deeper zones, and we may conclude that these beds were deposited in a depth of not less than 40 fathoms. Of course there may have been changes of level, and some lived in shallower waters, but not less than 40 fathoms may be taken to be the general indication, which is also apparent from the Terebratulae on which many of them grew.

In considering the number of species, we must remember that they were not collected by anyone who went purposely to collect Bryozoa, but I presume casually with other fossils, and that many might thus escape detection; and this is borne out by only finding one imperfect fragment of Idmonea and one of Salicornaria, both of which we may, from the examination of neighbouring deposits, conclude were abundant, and when we also think how large a proportion of the Bryozoa are incapable of or are seldom fossilized, it is apparent that these seas were inhabited by a large Bryozoan fauna.

In considering more in detail some of the species, I have already noticed that there are many cases where Eschara and Lepralia have similar zooecia (cells), and that in this small collection two cases of the kind occur—the one Lepralia biaperta, as an Eschara, and the other Biflustra rynchota, with cells like a Membranipora from the Crag. There are also cases where Lepralia can grow as an erect form for a short space, and such suggest the consideration as to how far Eschara and Lepralia are satisfactory genera, and I must say the conclusion I have arrived at is that they are very

artificial. A great part of zoological and paleontological classification must be artificial, and may often be none the less useful, and I therefore hope that until there is much more information on what to base classification, that they will be retained, and regret some attempts which I regard as premature to largely subdivide these into new genera.

D'Orbigny based his classification upon many characters, without understanding their zoological signification, and the consequence was that some forms could actually belong to several genera, and the confusion of his classification was in some cases very great. Since then, Busk, Reuss, and others have rescued these animals from the confusion of classification in which they then were: however, there are some principles introduced by D'Orbigny which might have perhaps well been retained. D'Orbigny attached much greater importance to the form of the cell than to the mode of aggregate growth, and in some cases signified the form of a colony by an affix, so that there was Eschara and Rept-eschara, the first erect and the second encrusting, so that on this principle, with such a form as fig. 8, the one from Bruccoli might be described as Eschara biaperta, and the ordinary one from the crag as Repteschara, and at once would be apparent not only what was the form of the colony but also of the cells.

A Swedish naturalist, Smitt, one of the most careful observers of the Bryozoa, attaches much more importance to the form of the cell (by which I mean the characteristic points in the aperture, the position and nature of the avicularia and vibracula, &c.) in generic classification than has been done by some in this country, and undoubtedly revision must some time be made of these groups of Lepralia, Eschara, and Membranipora, which have now, by the addition of so many new forms, living and fossil, become inconveniently large.

	Crag.	Pliocene	Miocene	Eocene	Chalk.	Living.	
1. Salciornaria farciminoides, Ell. and Sol.	+	+	+	..	+	+	Naples
2. Membranipora bidens, Hag.	..	+	+	..	..	+	Naples
2a. —— Lacroixii, Sav.	..	..	..	..	..	+	..
3. —— andegavensis ..... var. papyracea	..	..	+?	..	..	..	..
4. —— angulosa, Rss.	..	+	+	+	?	+	Naples
5. Lepralia ciliata, Pall	+	+	+	..	..	+	Naples
6. —— Morrisiana, Busk....	+	+	..	..	..	..	..
7. —— vulgaris. Moll.	..	+	+	..	..	+	Naples
8. —— coccinea, Abild.....	?	+	+	+	..	+	Naples
9. —— innominata, Couch ..	+	+	..	..	..	+	Naples
10. —— arrecta, Rss.	..	+?	+	..	..	..	..
11. —— ansata, John.	+	+	+	..	..	+	Naples
12. —— auriculata, Hass	..	..	..	..	..	+	Naples
13. —— do. var. Leontiniensis	..	..	..	..	..	..	..
14. —— cupulata, Manz.	..	+	+	..	..	+	Naples
15. —— Bowerbankia, Busk..	+	+	..	..	..	..	..
16. —— resupinata, Manz. ..	..	+	..	..	..	..	Naples
17. —— scripta, Rss.	..	+	+	..	..	+	Naples
18. —— Pallasiana, Moll.	+	+	..	..	..	+	Naples
19. Cellepora coronopus, S. Wood	+	+	..	..	..	+	Naples
20. —— tubigera, Busk.....	+	+	..	..	..	+	Naples
21. —— ramulosa, Linn.	+	+	..	..	..	+	Naples
22. Hippothoa catenularia, Jame.	..	+	..	..	..	+	Naples
23. Eschara lunaris, nov. sp...	..	+	..	..	..	+	Naples
24. —— cervicornis, Ell. & Sol.	..	+	+?	..	..	+	Naples
25. —— biaperta, Mich. .... var. eschariformis	..	..	..	..	..	..	..
26. —— pertusa, M. Ed.	+	+	+	..	..	..	..
27. —— foliacea, var. fascialis.	..	+	..	..	..	+	Naples
28. Biflustra rynchota, nov. sp.	..	..	..	..	..	..	..
29. Retepora cellulosa, Linn...	+	+	+	..	..	+	Naples
30. Myriozoon truncatum, Pall.	..	+	+	..	..	+	Naples
31. Cupularia Reussiana, Manz.	+?	+	..	..	..	+	Naples
32. Diastopora flabellum, Rss..	+	+	+	..	..	+	?
33. Alecto major, Landsb.	+	+	..	..	..	+	Naples

	Crag.	Pliocene	Miocene	Eocene.	Chalk.	Living.	
34. Pustulopora proboscidea, M. Ed.	..	..	..	..	..	+	Naples
35. —— rugosa, d'Orb.	..	..	+	..	+	+	Naples
36. Discoporella Mediterranea, Blain	..	+	..	..	..	+	Naples
37. —— radiata, Aud.	..	..	..	..	..	+	Naples
38. Diastopora cupula, d'Orb.	..	..	..	..	+	..	..
39. Frondipora reticulata .... forma verrucosa	..	..	..	..	..	+	Naples
40. Mesenteripora, sp.	..	..	..	..	..	..	..
41. Hornera frondiculata, Lam.	+	+	..	..	..	+	Naples
42. Idmonea, sp.	..	..	..	..	..	..	..
43. Caberia Boryi. Aud.	..	..	..	..	..	+	..

EXPLANATION OF FIGURES.

Fig. 1. Biflustra rynchota, nov.
Fig. 2. Lepralia Morrisiana, Busk.
Fig. 3. Membranipora andegavensis.—var papyracea.
Fig. 4. Eschara pertusa, M. Ed.
Fig. 5. Lepralia auriculata.—var Leontiniensis, $\frac{3}{4}$
Fig. 6. —— cupulata, Manz.
Fig. 7. —— resupinata, Manz.
Fig. 8. Eschara biaperta.—var eschariformis.
Fig. 9. —— lunaris, nov.
Fig. 10. Membranipora Lacroixii.
Fig. 11. Discoporella mediterranea, M. Ed.
Fig. 12. —— ditto
Fig. 13, 14. Diastopora, cupula, d'Orb.
Fig. 15. Pustulopora rugosa, d'Orb.
Fig 16. Alecto.
Fig. 17. Mesenteripora, sp. end of frond.
Fig. 18. —— showing rugose surface.
Fig. 19. —— small frond.
Fig. 20, 21. Cellepora tubigera, Busk.
Fig. 22. Lepralia vulgaris, Moll.

ON LIGHTING SHOTS IN MINES.

By Mr. Alexander Sutherland, of Carrickfergus.

Communicated by Mr. Joseph Dickinson.

A few months ago we were sinking a shaft through hard basaltic rock, which had to be blasted by dynamite. The man in charge was an experienced miner, and well up to this kind of work, but he frequently expressed his dissatisfaction at the large quantity of fuse he used.

"I cannot help it, he said, because my way of escape is so "slow,—either up this old ladder or in the bucket, and "neither to be much trusted. The other day a round of the "ladder broke with me when coming up after firing the "fuse, and I fell to the bottom, and was just in time to cut "off the lighted end of the fuse. I was only six or eight "feet up when the round broke, and had I been stunned by "the fall I should have been blown up too. I fastened a "piece of chain to a rope, made a few of the links red hot, "and, lowering it down, fired the fuse, but this is by no "means satisfactory, and the 'snuff' process is often terribly "slow."

Sometime previously I gave him a small apparatus to fire his shots by electricity, but the men did not understand it, besides it was deficient, excepting in experienced hands.

A few months ago an article in the "Mining World," entitled "Dynamite and Cotton Powder," commenting on the report of Major A. Ford, R.A., the Government Inspector of explosives, into the circumstances attending the explosion on August 23rd, in the London and North-Western Railway tunnel, near Festiniog, says the method of igniting the fuses, which is worthy of untutored savages, rather than practical miners, renders it surprising, not that a few men have been killed, but that the deaths are not of daily occur-

rence. Describing the manner of firing, Major Ford states that "the end of the piece of fuse projecting from the hole "is secured to the rock by means of clay, and a small piece "of candle (called by the men a 'snuff") is fixed also with "clay below the loop thus formed, so that when lighted the "flame shall be in contact with the outside of the fuse. If "the fuse were simply ignited at the end, the flame would "pass very rapidly through it to the charge, and there "would not be time enough for the men to get out of the "way, indeed some of the charges would in all probability "be fired before all the fuses could be ignited; but by "placing the snuffs in the position described, the fuse must "be burnt through before the gunpowder in the interior "thereof is reached, and a considerable time consequently "elapses before the first report is heard. As soon as all the "snuffs are secured to the rock they are rapidly lighted, and "the firemen withdraw out of danger."

The necessity of some practical method of firing fuses struck me so forcibly that it ultimately became the mother of invention, and the little modest apparatus sent you is the result of a series of experiments towards this end.

My earlier experiments were with preparations of gun cotton and xyloidin, but the temperatures required to explode these substances were below that of gunpowder, and consequently failed to ignite the fuse; besides, I found they were liable to spontaneous ignition. I succeeded better by immersing cotton wool in a saturated solution of chlorate of potass, and made the ignition more lasting and vehement by the admixture of sugar. The proportions giving the best results were 3 of chlorate of potass to 1 of crystallised sugar. When completely saturated, the prepared cotton was thoroughly dried in a water bath. It is hygroscopic, but retains its full igniting powers even after lying several months in the dampest parts of the mines. It will not ignite spontaneously. This preparation, however, requires sulphuric acid to effect its ignition. The apparatus consists

of a cylinder containing a sufficient quantity of the acid for say a hundred shots, and is so constructed that it is impossible the acid can drop on the cotton excepting at the will of the fireman. This is essentially requisite so as to guard against accidents.

The charge is made in the usual manner, but the fuse is cut off within say 1½in. above the top of the hole. The instrument is laid on the top of the fuse, so that the fuse passes up through the hole and into the little cup, into which a small portion of cotton is laid. A cord is attached to a little spring lever communicating with the cylinder containing the acid; the end of this cord is conveyed to a place of safety, and, when pulled, draws round the cylinder, the acid from which, through the pipette, drops on the cotton, which instantly ignites, firing the fuse. The cylinder immediately returns to its original position. The instrument can be drawn out of danger of the explosion. It is necessary the little cup should be cleaned out before setting the instrument for another firing.

Many modifications in the mechanism of this instrument suggest themselves, and it could also be constructed so that the cotton in the cup could be fired under a gauze cover.

Several of them could be set so as to be fired by one cord issuing from one common centre. I mean that cords from several instruments could be attached, by a simple contrivance, to one single cord, the pulling of which would operate on all the other attached cords.

The great objection to this instrument is the necessity of using sulphuric acid, which must be contained in a cylinder of lead, which is liable to become injured. Of course this could be cased in an iron cover, yet the necessity of using acid at all is objectionable.

To obviate this difficulty, I have devised an instrument which ignites a preparation of phosphorus against a corrugated steel disc in contact with the end of the fuse. When

perfected, I believe for simplicity, lightness, and efficiency it will be considered a boon to those engaged in blasting, and I hope be the means of preventing many accidents.

The PRESIDENT said: Mr. Sutherland refers to the principal methods in common use for lighting shots, as well as to other methods which are used on special occasions. It is, I think, between 40 and 50 years since safety fuse came into use. Before that time the straw, or a paper squib, filled with fine powder, with touch-paper or a small piece of candle-wick, or other slow match, were in use. Even still they are not uncommon in some mines; and in rock-salt mines, where sometimes about one hundred pounds of powder are fired in a day, the straw and wick are almost, if not exclusively used. In using squibs, or straws, a pricker has to be used whilst the stemming is being done, in order to leave a hole for inserting the straw or squib. Shots in this way are fired quickly, and with seldom any accident, and they make less smoke than fuse. With fuse no pricker is needed, nor is any other slow match except the fuse itself considered essential, sufficient length of fuse being left to allow time for the person who lights it to get out of the way. In coal mines in this part of the country, where blasting is extensively practised, the pricker and straw has chiefly been substituted by the fuse. Where safety lamps are used as an extra precaution, but where the mine is adequately ventilated, and it is considered safe to fire shots, the fuse is usually lighted by a fine wire, called a snuffing wire, which is heated through the gauze, otherwise the lamp has to be opened by the shot-lighter. In sinking pits through strong feeders of fire-damp, where blasting is indispensable, the shots have sometimes to be lighted by a hot ring guided by a wire. Electricity, percussion caps, or such like, might be made to serve the purpose; but they are not found in practice to be so convenient, and are only used on special occasions. In

using dynamite, which requires percussive force, fire is usually communicated to the detonator by fuse or other slow match in the ordinary way. Mr. Sutherland states the reason why he gave up using electricity; and it is easy to imagine other reasons quite as valid why the use has not become general where numerous shots are being daily fired in various parts of a mine. He also quotes Major Ford's condemnation of the use of the "snuff" as a slow match, but suggests no substitute except his own proposed apparatus, which may not be universally accepted. It is, of course, essential, before lighting a fuse or slow match, that precaution should be taken to ensure a retreat, and to see that no other person comes inadvertently in the way between the lighting and the going-off of the shot. Occasionally, however, as Mr. Sutherland points out, accidents are liable to happen from a person being unable to get out of the way, especially in the bottom of a pit. Accidents have also occasionally happened from bad fuse firing too quickly, and from the inadvertant lighting of the powder in the squib or straw instead of the slow match. Possibly some of the numerous practical mining members of this Society can suggest improvements upon the common methods of lighting shots, and upon Mr. Sutherland's method, which may be of service. In reference to Mr. Sutherland's invention, the PRESIDENT said that when the apparatus was shown to him, the first question he asked as, "How would you get the apparatus out of the way, when the shot goes off, lest it should be blown to pieces?" Mr. Sutherland replied that it was to be drawn out of the way by the string which puts it into action.

Mr. PICKUP expressed his belief that there would be great difficulty in preventing the apparatus from being destroyed. He had always followed the old plan of lighting shots by means of a fuse.

Mr. PEACE also said that at his mines the ordinary fuse was used.

Mr. BARRETT said that, in using dynamite, the shots were fired by electricity from the surface, care being always taken that the men were drawn out of harm's way. There was a conducting-wire down the pit, from which five or six branch-wires were led, each of which fired a shot,—these branch-wires being destroyed or rendered useless by the explosion. The main wire, however, was not injured. With gunpowder they used an ordinary fuse.

Mr. PLACE and Mr. SEDDON said that in their mines, where gunpowder was used, each shot was fired by means of a fuse.

Mr. G. C. GREENWELL, jun., said he did not think there were many mines where lives would be placed at risk through the breaking of the ring of a ladder. He saw the same difficulty with regard to Mr. Southern's apparatus as had been mentioned by previous speakers—namely, the difficulty of getting it out of the way. Apart from that, he thought there would be great objection to its use, especially by the men.

Mr. WILD said it was ten or a dozen years since he had anything to do with shot-firing. A good double fuse, burning about 3ft. per minute—giving sufficient time, in tunnels, for the men to get out of the way—was, he thought sufficiently safe, except where gas happened to be. Coal gas was readily ignited by the heat given off.

Mr. MARTIN said that electricity had been tried in West phalia at several mines for shot-firing; but from some causes—probably difficulties with the men in using it, combined with the trouble of keeping it in working order, and the immunity from accident with the ordinary methods. It was never carried much beyond the experimental stage.

Mr. COWBURN said he had often heard old miners express an opinion favourable to the straw. They said that there were fewer accidents from its use; but to his mind the fuse was a great improvement. Great difficulty would be found in firing shots with the straw in a wet place. At the same time

he thought the electrical machine was a great improvement on the fuse, where there was water in any quantity. The difficulty would not, in his judgment, be greater with an electrical machine than with Mr. Sutherland's apparatus. The latter would encounter quite as much prejudice as electricity did.

The PRESIDENT asked if Mr. Cowburn had tried electricity practically for firing shots in an ordinary mine.

Mr. COWBURN said, Electricity has recently been tried for sinking at Mr. Speakman's Wood End Colliery, near Leigh, where a large quantity of water was given off, and it answered remarkably well. It is by far the safest, and will be found as economical as any other process in the long run.

Mr. WOODWARD said they always used the ordinary fuse, both in sinking and coal blasting, and he had not known, during a considerable number of years, any accident to arise from it. He had had some idea of trying electricity, but having heard something said against it, and been told that it did not answer, he had not brought it into use. But he had heard lately that it had been very largely and successfully introduced into some of the Welsh slate quarries, and if they could use it there he saw no special reason why it might not also be adopted in sinking pits. The blowing away of a few yards of wire was no great matter: it was not to be weighed against the perfect safety of their men. As to the straw, he could not say that he had ever seen that used in coal or rod blasting in Lancashire.

Mr. SMITH (Bower Colliery) said he belonged to the old school, as regarded the lighting of shots, believing that nothing could exceed the ordinary fuse for safety. He had been for some twenty years engaged in a mine where, he thought, as much gunpowder was used as in any mine in Lancashire, and nothing was used there but the common single-tape fuse. The men worked with naked lights. There had never been an accident, nor had there been one at the Moston Colliery, through the lighting of a shot; and

he thought if miners were sufficiently careful no accident need ever occur from the fuse. He had come to the conclusion that for all practical purposes the tape fuse, if the place was wet, or the gutta percha fuse if it was extra wet, could not be excelled. He did not think, although they fired 40 or 50 shots per day, there were three missed shots in the course of the year.

Mr. Ralph Fletcher, jun., said he agreed generally with the opinion which had been expressed, that if ordinary precautions were used by their men, and if there was a good engine to pull them out of the way when the shots were fired in sinking pits, &c., the risk of accident from use of the fuse was infinitesimal.

The President said that thousands of shots were fired daily in mines, and accidents from the lighting of those shots were very rare indeed. It is not uncommon to use a "snuff" as a precaution in addition to the safety fuse where the lighting of the mine is with open lights.

NOTE.

At the ensuing meeting the President read the following letter from Major Ford:—

Home Office, 29th May.

Dear Mr. Dickinson,—

I have not seen the article in the "Mining World" to which you refer in your letter, of the 24th May, to Major Mejendie. Would you kindly tell me the date of the paper, and I will try to get a copy?

The opinion as to the use of "snuffs" is that of the writer of that article, not *mine*. You will see in the report to which it refers (copy enclosed) that I merely described the method, so as to explain what was, in my opinion, the cause of the accident. I did not express any opinion as *how* this might be improved on.

Very truly yours,

A. Ford.

Joseph Dickinson, Esq.,

Pendleton, Near Manchester.

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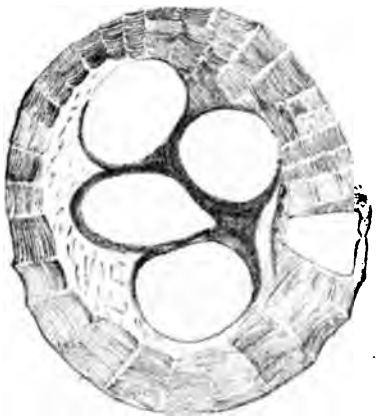

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Fig. 4

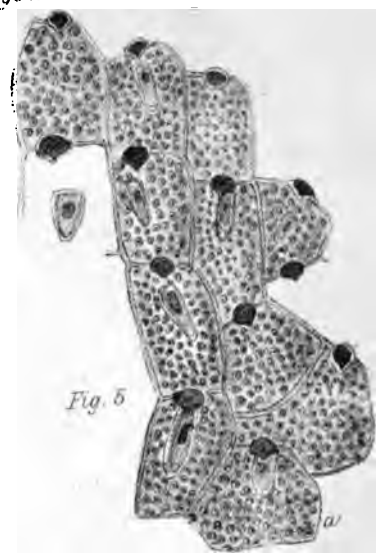


Fig. 5

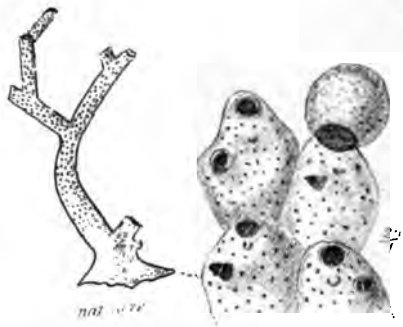


Fig. 9.

Fig. 11

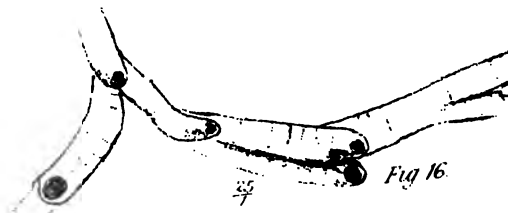


Fig 16.

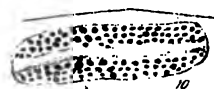


Fig. 17

Fig 18

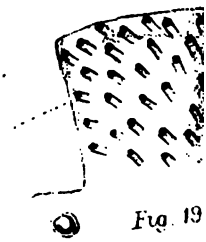


Fig. 19

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XXII. VOL. XIV. SESSION 1877-8.

The CONCLUDING MEETING of the Society for the Session was held on Tuesday, June 25th, 1878, at the Rooms of the Literary and Philosophical Society, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., President,
in the Chair.

The following communication from Mr. Binney was read:

"55, Peter Street, Manchester,
"21st June, 1878.

"J. E. Forbes, Esq., F.G.S.

"Dear Sir,

"Owing to my absence from town, I shall not be able to be present at the Meeting of the Manchester Geological Society next Tuesday. I wish to direct the attention of the members to a paper printed in Part XIX. of the Transactions of the Society, by Charles E. De Rance, Esq., Assoc. Inst. C.E., F.G.S., on the "Palæozoic and Secondary Rocks of England as a source of Water Supply for towns and districts." In this communication the author gives some tables on the mortality in towns where hard and soft water are used, from the Report of the Rivers Pollution Commissioners, published some time in 1874, and from his remarks, he does not appear to have been aware of what I had published on the same subject in March, 1873. Will

you oblige me by reading at the Meeting, the accompanying report of my paper in the Proceedings of the Literary and Philosophical Society of Manchester.

"I remain,

"Yours truly,

"EDWD. WM. BINNEY.

"One of the Hon. Secs. of the
Manchester Geological Society."

"Ordinary Meeting, March 18th, 1873.

"J. P. JOULE, D.C.L., LL.D., F.R.S., &c., President, in the Chair.

"E. W. BINNEY, F.R.S., V.P., said that during the last week an interesting controversy had been going on in this city between the Town Clerk and the Professor of Chemistry at the Royal Institution, as to the quality of the water supplied to Manchester. These disputants are well able to wage their own warfare, therefore it is not my intention to interfere with them. In these days no one doubts the blessings of a constant supply of pure and good water; but the latter quality is determined in a great measure by the purpose for which it is intended to be used. If for manufacturing and washing, then a pure soft water is no doubt most desirable; but it is very questionable if such a water, when conveyed any considerable distance in leaden pipes, is the best for the drinking purposes of a town population.

"In the Report of the Commissioners for Inquiring into the State of Large Towns and Populous Districts, Dr. Lyon Playfair, the Commissioner who reported on the then supply of Manchester, appears to have directed little attention to the quality of drinking water for a town population which had to a great extent left off using the milk, porridge, brown bread, and oatcake of our forefathers, and resorted to sloppy tea, white bread, butter, and a little meat, for at page 411 of his Report, he says:—'In considering the best means for

the extension of this benefit,' alluding to a constant supply, 'to the working classes, or in sanctioning the formation of new waterworks, it would be highly advisable to obtain evidence as to the quality of the water, particularly with regard to its hardness. The value of attention to this point will be obvious, when the difference of consumption of soap is considered. I found by various trials in summer, that the Manchester water possesses a hardness equivalent of what would be obtained if 13 or 14 grains of chalk were dissolved in a gallon of pure water.' The learned Commissioner gives the water at Aberdeen at one grain of chalk per gallon, and comparing that with the 14 of Manchester and the 12 of London, he concludes, 'Thus the hard water of Manchester may be regarded as increasing the water rent to a family of five individuals 16s. 8d. per annum, or £49,363 per annum to the whole town, a sum nearly double that of the present water rental. But large as the cost entailed upon a town by a bad selection of water in the unnecessary consumption of soap, still greater loss is incurred in the wear and tear of clothes.' This was written about thirty years since, and I have not the death-rate of Manchester in 1842. In that space of time, how much money has been expended in Manchester by the public authorities in shutting up cellar dwellings, closing grave yards, removing pigstyes, altering ashpits and middens, opening new streets, and supplying pure water? I cannot tell its amount, but every ratepayer knows practically that it is very large. In looking at the rate of mortality for the week ending March 8th, as given in the *Manchester Guardian*, in the 21 leading places in the kingdom, it was at the annual rate of 28 per thousand. In London, the rate was 27; Bristol, 31; Wolverhampton, 28; Birmingham, 28; Nottingham, 27; Liverpool, 31; Manchester, 36; Bradford, 26; Sheffield, 27; Newcastle-on-Tyne, 31. Now I believe the first-named five towns are

supplied with hard water, and give an aggregate of 141, whilst the latter five are supplied with soft water, and give an aggregate of 151. This is a significant fact and worthy of grave consideration. True, it is only one week, and a whole year ought to be examined, but I imagine the results, if carefully gone into, will give no advantage to the use of pure soft water when compared with hard, for 27 is a very high rate for London. In building up the skeleton of an adult, large quantities of the phosphates and carbonates of limes are required. The well-to-do, who consume plenty of butchers' meat, cheese, and new milk, may manage to obtain what nature requires, but for the poor, who live on sloppy tea, fine white bread, a little butter, a trifle of meat, and plenty of soft water, where are they to get their necessary supply from? It is not my intention to assert that the high rate of mortality is all due to soft water. No doubt there are many causes which help to produce it, but good, wholesome drinking water, containing carbonate of lime, and plenty of fresh air, which is hard to get in a close and crooked-built town of high warehouses, have in my opinion much to do with it. In my own case, I put a little lime in the drinking water used in my house, and I live on a sandy hill, well exposed to the winds of heaven. In all sanitary arrangements, too much attention cannot be given to providing plenty of fresh air and as much light as practicable."

The PRESIDENT said he was sorry Mr. Binney's health did not appear to be strong enough to admit of his giving that attention both to the Geological Society and the Literary and Philosophical Society which he had given for so many years. They missed him much at those meetings, but must under the circumstances submit to his absence.

EXPLOSIONS IN MINES.

Mr. GEORGE WILD read the following paper on: "Explosions of Fire Damp, and whether they can be avoided, or their severity mitigated:"—

As the subject of the present paper has been so ably written upon and discussed before the Society previously. An apology from me would be necessary for again introducing it, were it not that, recurrences of calamities, the most appalling in nature of any connected with coal mining, arouse our sympathy for the sufferers and also our interest in the matter of self-preservation, a feeling intensely quickened by the serious character of many recent explosions as well as by the conclusions arrived at, from investigation into such cases as the Blantyre and other accidents.

The object of this paper is to express a few plain and practical suggestions, in the hope that the best means of avoiding, or at least mitigating the sacrifice of life from explosions of fire-damp may be elicited in discussion.

Part of the last paragraph would seem to imply that explosions are to be considered as inevitable and that alleviation of consequent sacrifices of life and suffering is all that we should aim at, in despair of entirely preventing their occurrence. Such however is not the feeling of the writer and such an idea will not I am sure have been for a moment entertained by the members of this and kindred Associations.

Whilst however we do not despair of ultimately vanquishing our subtle foe and thus entirely preventing explosions it is our imperative duty to seek for and adopt all reasonable means to minimize their disastrous effects,—and for this reason should examine the various sources from which they arise.

One source of danger, common to some districts, though not often known to be the cause of explosions, is worthy of

serious consideration, viz., *spontaneous combustion*. Having had very limited experience in this form of difficulty, with the exception of heap-fires on the surface, I can say but little as to their avoidability.

Elements highly favourable to chemical action, and consequently to cumulative heat, must be present from the fact that a sort of liquifaction of the hydro-carbon takes place previous to actual combustion, rounding off the angles of the coal, which, from their exposed form, are most easily acted upon, producing a tarry substance, the germ of spontaneous combustion; the generation of which is no doubt accelerated by the sulphur, oxygen, and phosporous,—highly combustible elements found in connection with the pyritized remains of fishes, met with immediately on the top of coal seams. These substances, becoming intermixed with the coal, probably lead to many of the underground fires, which take place when the necessary conditions of moisture limitation of air, and to some extent, heat-producing pressure are present. We also find in the shales, salts, in the production of which sulphuric acid takes an active part, generating a degree of heat, which, when the necessary conditions are present, is sufficient to account for some of the phenomena warning us of the near approach of actual combustion. The precaution against this kind of accident will be best understood by gentlemen possessed of much experience in such cases,—opinions widely diverging as to the best means not being uncommon.

The most serious, and, at the same time, most unavoidable accidents in connection with mining, which are under the present efficient system of inspection, management, and colliery appliances most to be feared, are those arising from the sudden and unexpected appearance of explosive gas in such quantities as to foul the otherwise well ventilated workings, thereby rendering a well-conditioned Davy-lamp unsafe,

even in the hands of a skilful miner. These influxes of gas arise in several ways, which are more or less unavoidable. *Depression of the barometer*, though not sudden, may, from a lessened pressure on the pores or fissures, from which the gas exudes, or from extensive goaf-cavities, allow sufficient expansion of the volume as to foul the ventilation. Yet cases have been met with in practice, where a slackened ventilation would often neutralize that effect, for a time proportionate to the extent of goaf-cavity ventilated. Another dangerous, and, to some extent, unavoidable cause is, a *sudden settling down* of the roof or upheaval of the floor in the goaves, when working homewards, undoubtedly often the cause of serious explosions by forcing out the gas upon a naked light, or, if you will allow me the paradox, unsafe safety lamp. The most to be dreaded, and, so far, the most unavoidable is the *outburst proper*, the avoidance of which, so far as practicable, is one of the objects of the writer in bringing before you the practical suggestions contained in this paper. Thirty to forty years ago, cases were rare in this part of the country, though very fiery mines were then being worked, in which more than three persons were injured by the same explosion; and the thought of danger to anyone not in the immediate vicinity of the accident was as rarely entertained. A peculiar sensation, commonly known as sucking in the ear, distinct from that of a heavy blown out shot, followed by a vibratory rattle at the air-doors, was the usual indication of gas having been ignited somewhere. Now, however, we have, in some cases, less fiery mines, worked with a sweeping ventilation, which, at that time, would have been thought sufficient for four such collieries. Yet explosions occur, terribly destructive to life and property; and awfully unconsoling, from the fact that often the whole of those from whom we might expect to glean the cause of the calamity are swept away, not wholly

by the fearful blast, the scorching flame, or the deadly after-damp, but (if no misunderstanding exists,) in a manner propounded by one of our most able and experienced mine inspectors—an idea for which he is responsible,—namely, killed instantly on the spot, pick, hammer, or shovel in hand, by some peculiar action of the atmosphere of the mine at the moment of explosion, whether by compression or rarefaction is not quite clear; but certain it is, tha great weight must be attached to that opinion, coming from the source it does. It is unconsoling, allow me to repeat, to find that, though the blast, the flame, and the poisonous after-damp may be escaped, yet another deadlly force comes into play, cutting off those who might have been of the greatest service to their stricken comrades, in at once directing the ventilation to its proper course, and extinguishing the germs, should any exist, of what might become a serious fire.

The avoidance of sudden influxes, and consequent liability to accidents arising therefrom, and to counteract, as much as possible, their disastrous effects, when they unfortunately occur, will be the aim of the suggestions put forth in the remaining portion of the paper.

What is an adequate amount of ventilation in fiery collieries to attain comparative security, depends so much upon the degree of its gaseous character, as well as the angle of inclination of the seam, and whether it be worked wholly on the dip, or rise, or a combination of the two; also, whether it be worked on the long-wall principle, and the whole of the coal extracted going outwards; or, on the pillar and stall system, working out the greater proportion of the coal homewards. That which would be amply sufficient for one colliery might not be one-sixth of what would be essential to the proper ventilation of another employing the same number of hands. So that whether we,

take 200 or 400 cubic feet per minute per person employed for ordinary ventilation we ought, even to meet common occurrences, to have an available surplus power of at least 20 per cent. additional.

But to cope with emergencies such as the sudden influxes of gas previously mentioned, ventilation the most powerful is not a certain remedy.

Perfecting the locking of the lamp is highly meritorious; but there are circumstances in connection with coal mining where it may be likened unto the boy locking up the bird in his bedroom, the window of which contained a broken square, and putting the key in his pocket, that no one might make the mistake of liberating his prisoner, until he returned from school. The prison was imperfect; the bird had flown. Now, we want the squares putting in order, that when we have locked our cage the bird (a bird of prey) may not escape and carnivorously glut himself. What I would suggest is the exclusive use of the best safety-lamp wherever gas is known to exist in dangerous quantity; and, let me observe, it is to be regretted that some scientific gentlemen have expressed themselves in such a manner as to lead the public to believe, that the exclusive use of the safety-lamp meant a substitute for good ventilation, and proper attention to meteorological phenomena. With all deference to meteorologists, and admiration of the invaluable science to which so much attention is at present devoted, and to which we owe so much for the knowledge we possess of the physical changes of the atmosphere, so much so as to enable us often to anticipate the immediate future effect of barometric and thermometric undulations, yet I am inclined to believe that atmospheric changes have but a small share in bringing about most of those direful calamities; and that the strictest attention to the construction of the lamp given us to work with, its proper trimming, locking, and the most careful use

on the part of the men and boys into whose hands it is entrusted, is of far greater service in averting an explosion than would be the labours of an expert meteorologist at every colliery, using telegraphic or telephonic communication with every part of the mine, ready to give warning of all atmospheric disturbances, if the above-mentioned precautions were neglected.

The fouling of the mine from an atmospheric state indicated by a depression of the barometer, is generally slow and under proper attention and discipline is detected by the workmen or officials in charge, by the state of their lamps, thus giving time to withdraw from the vitiated part to one more safe, whilst we find that most of the sources of greatest danger namely, sudden influxes of gas are almost entirely independent of barometric influence. There is one point I wish to mention before leaving this part of the subject namely, that it is understood to be advisable in the event of a depression of the barometer to increase the firing at the furnace to keep up or increase the ventilation, in order to carry away harmlessly the increased quantity of gas exuding from the coal and shale, owing to the lessened pressure on the pores of exit. This undoubtedly has the desired effect of keeping up the ventilation, but it has often been found in practice, that a greater quantity of gas is brought from the groaves into the return airways under an increased heat in the upcast shaft. Whether arising from a greater rarefaction of the column causing an increased flow of foul air in that direction or the insinuation of the increased ventilation into partially ventilated goaves is a point upon which the writer is not quite clear and would be glad to know if this accords with the experience of others present, and, as it might in some cases be found dangerous to disturb a body of gas from the goaves during working hours, an opinion on the matter by some one more able and

experienced would probably lead to beneficial results, by throwing light on the subject.

In sinking, when approaching a fiery seam of coal it is sometimes necessary to use a covered light, owing to the presence of explosive gas, which, existing under enormous pressure from the super-incumbent strata has acquired a density, and, from its elasticity in the gaseous state, a power sufficient to break through many feet thick of solid shale. A description of the chemical properties of fire-damp and whether it is possible for its constituents to exist so highly condensed, under the enormous pressure to which it is subjected, as to be in a liquified or even solidified state, is the province of the chemist. What the miner knows about it is; that it is a dangerous element to work in the midst of, and he often wonders from what source such a quantity can be for years so continuously supplied; that it is there and must be dealt with if the coal must be won, he also knows, and prepares himself with the best known means of dealing with it. The means resorted to in the first place are covered lights, known as safety-lamps, by which he is enabled to connect the shafts, and lay out the mine for ventilation and coal winning. If the lamp with which this work is to be performed was under all circumstances, when in good order, what its name implies, the work of coal mining with all its other attendant dangers would be one in which the higher class of skill with careful attention and strict discipline would be sure to find its reward in the unfrequency of accidents. But, that we do not possess a safety-lamp, save in name, and that it never was considered so by the inventors, is well known. Even Sir Humphrey Davy on introducing his lamp to the eminent mining engineer, Mr. Buddle, placed the lamp in the engine-house and played upon it with a jet of pit-gas at the distance of 8 to 10 feet until he ignited it at the flame inside the lamp or

the heated gauze, to show its insecurity under circumstances by no means rare in the highly gaseous and powerfully ventilated coal mines of the present day, that insecurity often setting at naught the most skilful and elaborate arrangements of the accomplished mining engineer.

That the experiments* carefully and scientifically conducted in different parts of the country conclusively prove that the Davy lamp, under circumstances frequently met with in very fiery and well-ventilated mines, is extremely unsafe we must all admit. That even the Stephenson type (which the writer has reason to think much the best in use) is far from being absolutely safe under all circumstances is proven by the experiments conducted under the auspices of the North of England Institute of Mining Engineers, whom we all know would not detract from the "Geordie" without reasonable cause, although it has stood well in the tests with coal gas at the Cannock and Rugely Collieries.* Yet even the Stephenson, without the perforated copper cap to arrest the heat in its ascent to the single diaphragm at the top, is extremely unsafe, as it then becomes dangerously heated; so that it is essential to even partial security that a good internal diaphragm be always maintained, or the lamp at once extinguished.

It may be said there is a great difference in the explosive properties of olefiant gas and the light carburetted hydrogen of the mines. Granted; but I think the margin not greater than necessary to give the degree of safety requisite to inspire the thoughtful miner with confidence. I may say that my reliance in the wide-gauzed Stephenson *versus* narrow-gauzed Davy as against a strong intermittent blower of gas, would be greatly lessened if, with a jet of common gas under the ordinary winter pressure of about 2in. water

* See experiments at Cannock and Rugely Collieries. *Colliery Guardian*, May 17, 1878.

gauge, an experimenter could pass the flame in one-fourth the time which would suffice for it to be passed through a narrow-gauzed Davy lamp; and, moreover, although happily not the actual experimenter, I have conclusive evidence of the flame of *light carburetted hydrogen* having been passed through a Davy in good condition, in the mine, in a very short time, confirming the opinion that the margin is not excessive for even comparative safety.

Without desire to shirk the share of responsibility which attaches to the position of manager of mines, it is only reasonable to expect that a certain amount ought to rest on the scientific world, and on the public, until they find us a safer lamp to light our dangerous occupation underground. We look to the public nationally for the means, and to our scientific gentlemen for the attention and skill necessary to master the problem.

True outbursts, which are the most unavoidable, are those arising from gas pent up under great pressure, suddenly bursting its bonds, consisting of the hitherto solid strata; the usual premonitory symptoms of which are, the crackling movement, the breaking of timber, the puffing up or settling down of floor or roof—symptoms usually followed by a noiseless yet often enormous exudation of gas, which should always be looked for during the movement, and particularly after the crackling has ceased, and the prison walls are shattered and breached. Cases have come under my experience in which the place of outburst had seemed to become quite settled before the gas began to issue, whilst such was the quantity afterwards given off, in the short space of a few minutes, that it filled roads of many hundred yards in length, to the explosive point, and continued the supply for nearly an hour, under a brisk ventilation. The area of the above-mentioned roads was nowhere less than 16 square feet, and the velocity dangerous even to the best safety lamp, unless

its property was *immediate-self-extinguishing*, a quality in the lamp which I feel persuaded is one of the best means of avoiding explosions in such cases.

It may be here remarked that in cases such as the above, until we have a substitute for flame-producing substances in the process of breaking down the hard and thick seams of coal, we may place blasting in the same category as the use of naked lights, except that we do not generally risk as much with candles as shot-firing.

This brings me now to what is probably the most interesting point for discussion, and one on which no doubt conflicting opinions will be found to exist, but it is one on which I can give my opinion with more confidence, as it is a difficulty with which I have had much experience.

How far sudden issues of gas may be prevented by the mode of laying out and working of a colliery is an important consideration, whether worked by open or covered lights; as the powerful ventilation of the present day is sufficient to distribute the gas through the ramifications of an extensive colliery so speedily, as to give little warning, and consequently little time to prepare for such emergency, by withdrawing the men from the districts affected.

As the circumstances connected with coal mining are varied, some very fiery and thin seams (not more than two to three feet thick,) being worked at great depths, with plenty of packing material; others from three to six feet thick; some with sufficient packing, others almost none, or disadvantageously situated in that respect; it would, no doubt, lead to the best results if the varied experiences were brought before the Society in a series of papers on the subject, and with that view I chiefly confine myself to conditions of which I have had personal experience, viz.:—A deep fiery mine, comparatively free from water, so far as relates to the coal seam itself, the seam from two to four feet thick,

with a gradient up to 9 or 10 degrees, or from a slight dip to about 1 in 6; a tender roof or floor, and furnishing packing material necessary for a 6 to 9 feet width of pack-wall on each side of drawing and air-roads.

A seam of coal so situated, if worked on the long-wall principle, and from rise to dip as soon and as much dipwards as practicable, will be found to effect a gradual drainage of the gas; thus, to a great extent, obviating the extreme danger attendant upon hastily cutting out fiery seams, and laying bare in a short space of time thousands of pores or fissures, which are constantly surcharging the long-coursed and often vitiated ventilation to a dangerous degree.

Where it is practicable to adopt long-wall, it will be found (contrary to the opinions of many) that the liability to danger from sudden falls of roof forcing gas from extensive reservoirs left behind is almost nil compared with that of working homewards. For, in the first place, working dipwards and outwards allows the gas (should any be given off from the roof or floor after the coal has been wholly extracted) to escape through the broken and subsiding shale, not only draining the roof and floor, but, in its gradual subsidence, lessening and ultimately destroying such a thing as goaf-cavity.

True there may exist a short space near the end of the walls, but gas is seldom found lodging there, as the ventilation sweeps the ends of the pack-walls and goaf-space quite as thoroughly as the face of work; and moreover, should any uneasiness in the goaf manifest itself, you are at once made aware of it by its affecting the drawing-roads, and you are able to communicate in a minute or two with every person along the whole face of the workings, each one being able in a few seconds to retire into the drawing-roads, which are in such cases places of refuge, or safe points of observation, from which all can safely retreat towards the shaft, or wait

until the movement ceases and danger is passed, when work can again begin.

The above advantages do not exist when working *pillar and stall*, where communication is rendered more difficult, and if gas was found to be escaping, probably the shortest way to get from place to place would be through the explosive mixture, which in all likelihood would have affected the other places on the return side to a very dangerous extent before information could be given; the consequence being that the workmen would have to make their escape, in many cases, a long distance through fouled air-ways.

The before-mentioned advantages are also absent when working homewards and leaving an unapproachable goaf behind, whilst the air-current takes the shortest course, sweeping the edge of the pillar of coal, leaving the waste behind stagnant, and more liable to become filled with gas from the solid coal than the long-wall goaf is, from which the whole of the coal has been extracted, and where no solid edge of gas-producing coal is left unventilated, until the whole district is wrought out. It is also very probable that under the conditions mentioned, that most dangerous practice of blasting coal in fiery seams might be generally, if not wholly, dispensed with.

In illustration of the views herein expressed of working long-wall dipwards I have prepared a sketch or plan which will no doubt clear up my meaning better than a multitude of words. I may just say that No. 1 would give at the same time both rise and dip coal, would furnish coal for each side of shaft which is often desirable, and would separate districts in such a manner as to lie entirely on opposite sides of the shafts. The districts would all be worked on the rise drainage system, except the extreme rise of districts No. 1, and be ventilated on the ascending principle, and from the

Line of Dip
Line of Cleavage
1
2
3
4
3
Reference
DD Air Doors
St Stoppings
Sh Sheets
Sc Scale of Air
Cr Crossings

direct manner of coursing the air (common to long-wall) along the working face to the rise returning along the top of the goaf to the direct main return, would, with very few exceptions, avoid double coursing and consequently that impediment to good ventilation an universal drag on the current. It would also furnish the greatest amount of coal in the most marketable condition and in the least space of time of any system of working coal with which the writer is acquainted. The other districts would follow in the order of their numbers, giving the same advantages in all respects. There are occasional difficulties which turn up unexpectedly to interfere with a prearranged plan. Yet if we lay down on fast lines a principle and the practical part is carried out in such a manner as to leave a striking resemblance of its parent, that is as much as can be reasonably expected from the varied changes incidental to coal mining.

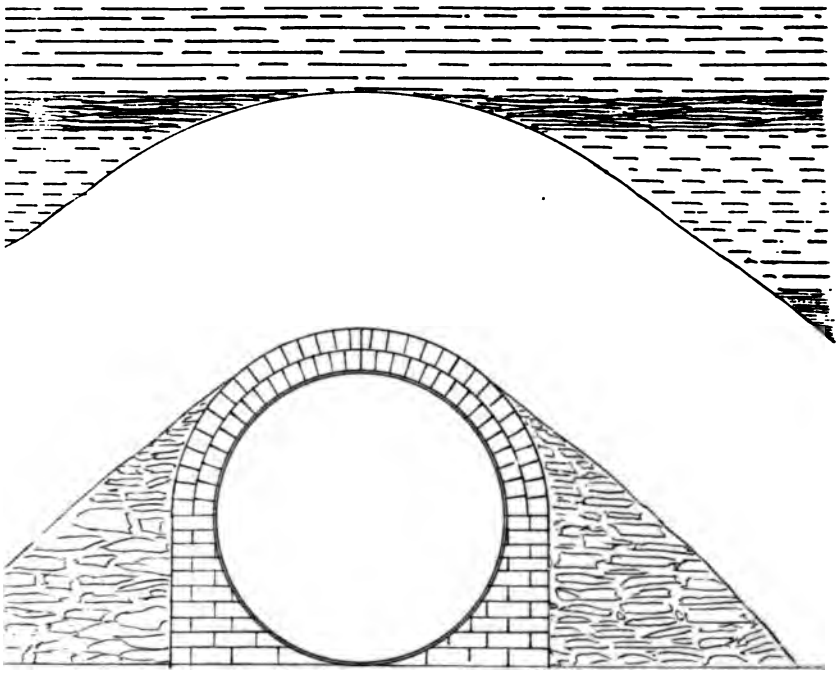
Having said this much on the means of avoidance I am afraid that for the amount of new matter contained, your patience as well as time will be "giving out," so will briefly offer a few suggestions as to mitigation of their severity, when we are unfortunately overtaken by such calamities, suggestions which if not properly matured, nor in every respect practicable, may perhaps elicit discussion and lead to a beneficial train of thought in that direction which is the writer's aim and will amply reward him.

Though the improved standard of education is beginning to be perceptible in the working miner, the attentive official, the skilful mine manager, and the accomplished mining engineer, it is to be feared we scarcely keep pace in our underground arrangements with the modern appliances appertaining to coal mining, which are bringing within reach, deep fiery mines at one time thought inaccessible, opening up mines at one time thought to be unworkable from their fiery character, raising a quantity of coal from

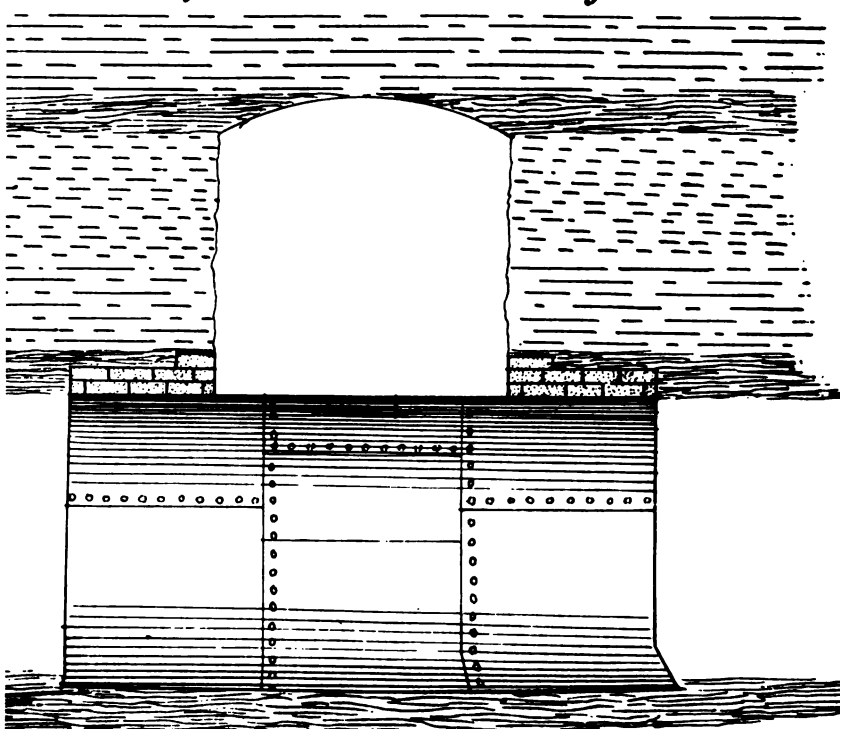
one pair of shafts that necessitates the employment of hundreds in place of scores, yet we somehow lack the painstaking attention to underground appliances necessary for cases of emergency, probably from over-sensitiveness, or, it may be, self-confidence, begetting a feeling that we shall continue to possess the immunity from such troubles as has been our good fortune hitherto. That the commercial nature of coal mining is a very risky one must be allowed; but, that parsimoniousness interferes with the necessary precautionary provisions cannot for a moment be entertained, as the substantial, magnificent—yea, ornamental—and costly character of the mechanical appliances above-ground prove.

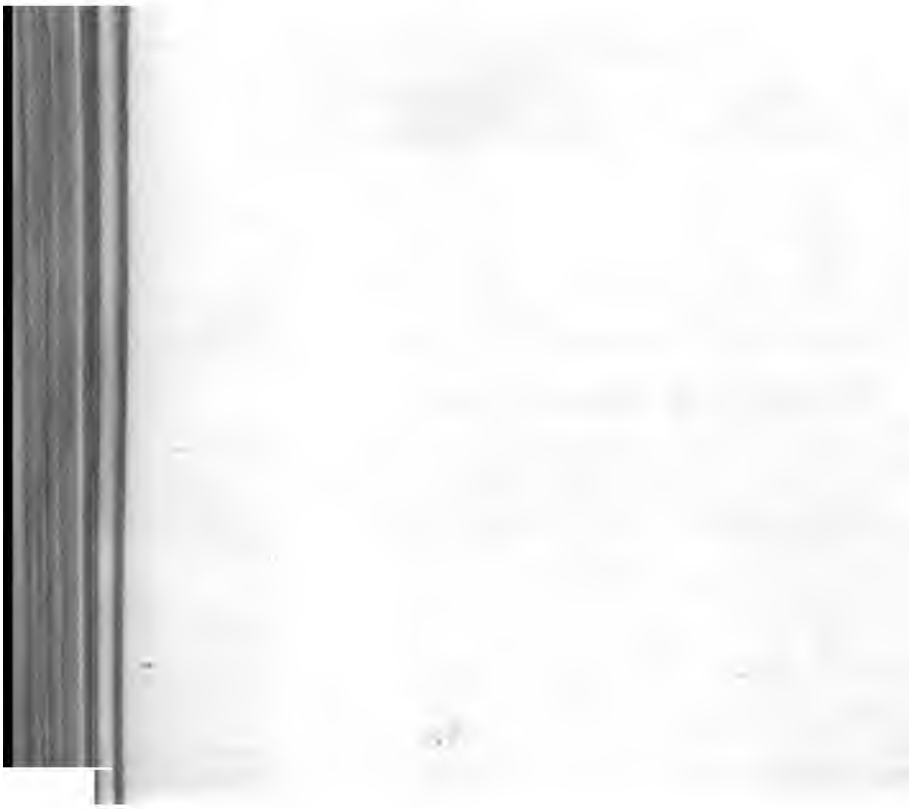
The question then arises, can anything more be done to mitigate the severity of the almost unavoidable accidents by which the most careful are too frequently overtaken, by improving, as far as possible, underground appliances for its attainment?

In seconding the efforts of our legislators through their servants, the mine inspectors, from whom is demanded at times almost superhuman skill and self-sacrificing exertions in the noble effort to save human life, the cost will undoubtedly be found a recuperative investment, by not only protecting the lives of the workmen, but also the property of the proprietors. Self-preservation is a powerful instinct in man as well as the lower order of animals, and it is perplexing to account for its seeming absence in the singular cases of death before alluded to; but whether from stupor, fright, hopeless resignation until overcome from want of the necessary air to support life, or an unnatural condition of the density of the atmosphere of the mine at the moment of explosion, that they do occur is undeniable, and in such a manner as to slay, as it were unconsciously, persons working at a great distance from the flame or blast. I think it possible to separate districts in such a manner



Wrought Iron Tubular Crossing





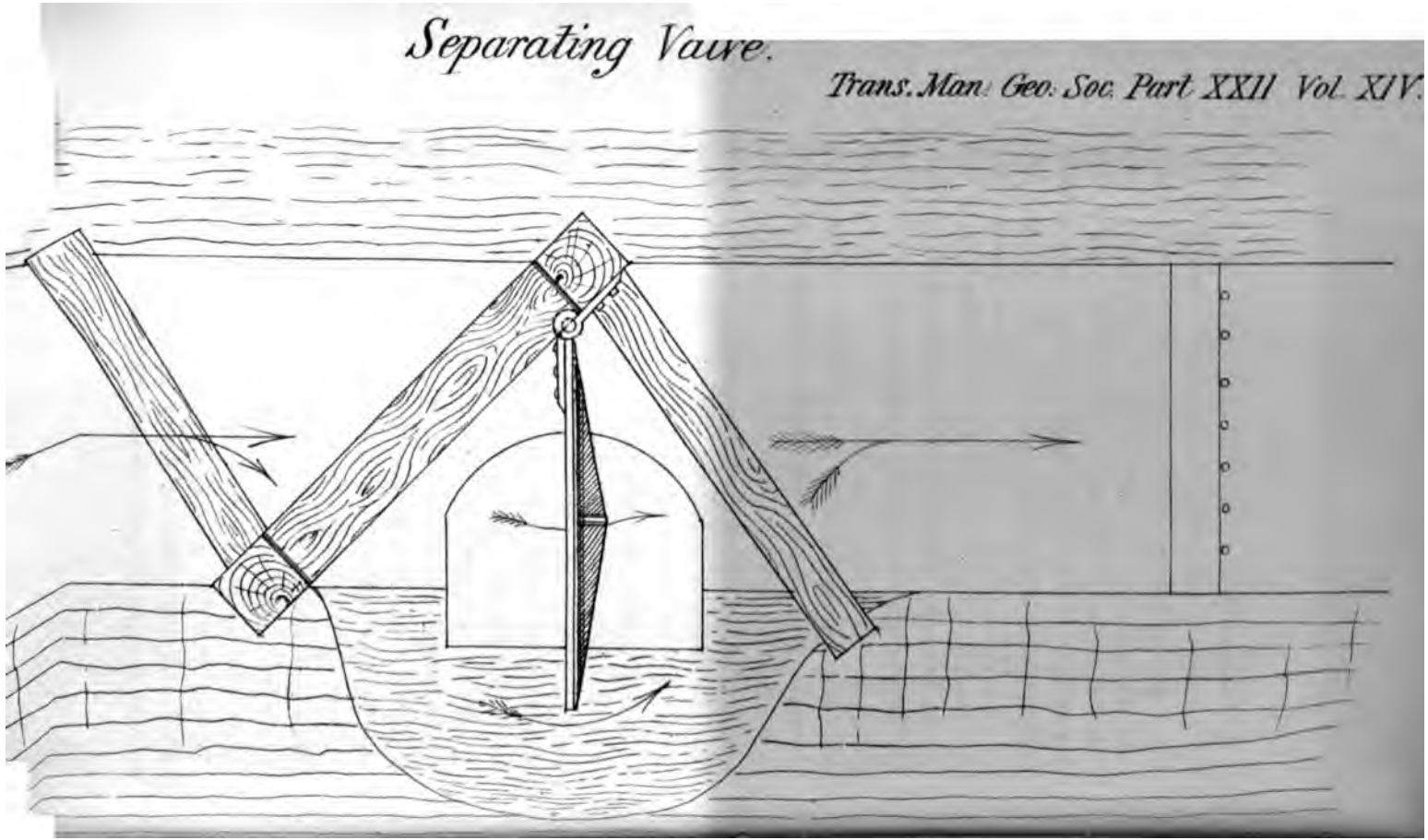
that, from their position (occupying opposite sides of the shafts, the most natural throat in case of rarefaction, or vent in case of compression), an explosion happening in one district may not so destructively affect the other. To accomplish that object it is indispensable that all crossings separating districts or main currents should be so constructed as to withstand the effects of the most severe explosion, which may be done by adopting the wrought-iron tubular crossing made of plates, the thickness of which may be proportionate to their diameter; in cases from 4 to 6 feet diameter, 5/16 to 3/8 inch would be amply sufficient, if well bolted together. The cost would be about 1s. 6d. per superficial square foot, and the duration of such crossings may be said to be, with slight repairs, the duration of the colliery, whilst the labour of making the cross-over and fixing the tubes need not be more than that of ordinary crossings. Other crossings of flat plates of iron, firmly bolted to stout wooden frames, forming either top or bottom of the roadways, will be found very durable and strong. Of course both kinds of crossing should be provided with man-holes fitted with sliding-doors to allow of passing through, when inspecting the air-ways.

As to air-doors, it is generally found that the present form of wooden ones succumb to a severe explosion, and instead of the ventilation partially recommencing, the air takes the shortest route, and if the winding apparatus be disarranged, the most valuable time—the first half-hour subsequent to an explosion—is lost, and the parties who very properly make towards the down-cast by the intake (which ought always to be the first point aimed at) are often struck down when they have advanced a considerable distance in the most likely direction of succour.

This it would seem might be obviated by supplementing each air-door by a specially-made air-sheet, strong enough to

hold its own under the most severe hurricane of wind or blast experienced in the mine. The chief requisites in such a sheet are strength and flexibility sufficient to allow of its adapting itself to the inequalities, if any, caused by *débris* from a strong blast. Non-inflammability should also be a weighty consideration. These qualities might no doubt be obtained by making a very strong cloth, and doubling it round a stout iron bar secured to the strong cross-cap of the sheet frame with eye bolts or strong bolt staples, and strongly stitched or rivetted immediately below the hanging bar. A flexible and strong sheet might also be made in a tasselled form of strong half-inch cord; and as closeness is not essential, if at all desirable, in such an emergency, this would no doubt serve the desired purpose. Strongest and best of all would be a light chain sheet, filled in the interstices with some non-inflammable fibrous substance, to render it partially air-proof. Sheets of this description coming into action immediately after the doors were destroyed would in many cases save the mine and valuable lives from destruction, by enabling a timely restoration of the ventilation, (especially in the dip workings and main roads leading from the downcast, and in many cases the whole of the workings, where an hour lost in organising exploring parties or repairing winding apparatus might sacrifice many lives), rendering it possible that the services of courageous officials who happen to be spared may be immediately available in extinguishing any small fires that might be discovered, thus nipping in the bud the germs of destructiveness.

Sheets might also be made of thin steel plates, overlapping as in a coat of mail, secured to light flat tapering hanging chains. The kind of article need only to be pointed out, and we generally find our manufacturers of specialities fully able to meet our requirements at very reasonable prices, provided the demand is worth their attention. I now


Separating Vaive.
Trans. Man. Geo. Soc. Part XXII Vol. XIV.

come to what may be considered the *stop-valve* for the temporary separation of districts. The suggestion I think one deserving of serious discussion, as to whether it could in any way be made to merit the appellation of *safety-valve*. What is proposed is, that each district shall have its various return air-ways contracted into one of due proportion, previous to joining with the other district or districts in the vicinity of the dumb drift. In the single road a very strong valve should be placed, and fitted in such a manner as to come into play for the moment, and effectually resist the force of a blast, and, in a great measure, the flame from all the other districts.

The blast being over, the door or valve should re-occupy its original position, allowing of its own district to again breathe freely.

Could this be successfully accomplished, there is very little doubt a great step would have been made towards mitigating danger.

The accompanying sketch will no doubt be understood by most acquainted with mining, and discussion on its merits or demerits, even if it end in rejecting the arrangement as impracticable, will, I trust, not be wholly unfruitful in directing attention to the matter.

In anticipation of the forcible questions which may be prominent in the minds of many who have had experience in such cases, of what use would be all these safety appliances in face of a mine charged with after-damp, heated to such a degree as almost to defy restoration, especially in rise workings, and which is often more than sufficient to neutralize the latent heat of powerful furnace flues and heated up-cast, my answer is this: If we have a furnace, and it cannot at the time be safely used in consequence of its imperfect isolation, or other cause, different means must be resorted to, to assist in again setting in motion the stagnant ventilation.

In passing, I may here remark that I fail to see the least advantage in any delay; long continuance in a heated state would bring down the roof and block up the roads, whilst with self-adjusting arrangements the ventilation would most likely be as easily restored in a heated as a cool state; in fact, dip-workings would be almost self-restorative, if great heat was produced in them, giving to up-cast shafts on the extreme rise a great advantage over other situations.

One of the oldest if not the best method for restoring the ventilation, in the absence of ventilating machinery, with which the writer is acquainted, is the pouring down a stream of water from the pumps, the immediate effect of which is well known to be a rush of wind at the bottom of the shaft, in many cases obtaining a pressure on the water-gauge of nearly one inch, which would seem sufficient in many cases to restore ventilation, providing the air-ways and their adjuncts were in proper order.

Where pit pumps are not required, very few engine-houses are without a pump of some description, which might be easily made available for supplying a cistern fixed in an elevated position by the side of the engine-house, and kept constantly full, in readiness for extinguishing any small fires which might break out about the surface buildings.

A cistern containing 3,000 gallons, or about 500 cubic feet capacity, would furnish water at the rate of 50 gallons per minute for an hour, or 100 per minute for half that time. This might be supplemented by the boiler pump, so as to keep up the supply some time longer. Or, in the event of failure of water supply, a very effective substitute might often be found in the shape of 5 or 10 tons of slack, a not very valuable commodity to the producer just now, and should it become so, the cost of raising it to the surface again would not be found unbearable.

Where a powerful fan is used, provided it escaped the effects of an explosion, if the water guage could readily be increased, the ventilation ought not to remain many minutes stagnant, and a flow of fresh air should soon be circulating, if not to the coal faces, at least a long distance on the main roads, restoring the sufferers from choke-damp, whose proportion is often large.

Since it is more than probable that the fan, or other machinery, with all its present drawbacks, will at no distant date supersede the furnace, except in very deep mines, immediate restoration of the ventilation to its usual course should be the first step taken, and a reversal checked at once, so that those who are spared, and have the presence of mind in such cases to make for the fresh or in-take air (a point which ought always be understood by both officials and workmen), may not only have a chance of saving themselves, but also of lending assistance to their more unfortunate comrades.

In conclusion, allow me to remark that in making these suggestions I do not ignore the sensitiveness to danger engendered in the mind of the miner by the adoption of such appliances. Still we anticipate over-winding, the breakage of ropes, and other serious accidents, which shortly begin to be appreciated; and, confronted as we are by the frequency of explosions, even in model collieries, it behoves us to take every means possible to avert or to alleviate them.

In answer to Mr. Greenwell and other gentlemen, Mr. Wild gave some further explanation with regard to his proposed stop valve. He could not, however, state the actual pressure in lbs. per square inch of the force of an explosion; except that, in cases with which he was acquainted the blasts had been very strong—breaking doors, but not doing a great deal of damage otherwise.

Mr. GRIMSHAW said he had seen, after an explosion, that the sleepers had remained perfect whilst the iron rails which overlaid them had been twisted like the wire round the cork of a soda-water bottle.

Mr. JOHN HIGSON said the explosive power of a mixture of light carboretted hydrogen and atmospheric air was enormous, and he did not believe Mr. Wild's proposed stop valve would be of the slightest use.

Mr. WILD said he thought, taking all things into consideration, that it would be quite possible to make the doors strong enough to resist any blast.

Mr. GRIMSHAW said Mr. Wild had referred to a plan adopted by Mr. Buddle. In reading some old reports, he (Mr. Grimshaw) found that at Wallsend, Mr. Buddle put up safety doors in a recess in the roof, which were to drop down in case of an explosion, but there was no evidence that these proved of use at any time. They were blown away in the last explosion at Wallsend—he believed in 1835.

Mr. WILD said the door he proposed would be bracketed behind, and made strong enough to resist a pressure of 100 lbs. to the square inch.

Mr. GREENWELL said the main question was—"Could any such appliance as Mr. Wild had described be constructed with sufficient power to produce the effect which he anticipated? At present they were without the basis for calculation. Leaving that question alone, therefore, for the present, there was another arising out of what Mr. Wild said, namely, as to increased ventilation under certain conditions of the atmosphere, when a greater quantity of gas might be expected to be given off, having the effect of bringing more gas out of the goaves. Would not the effect necessarily be if additional pressure were put upon the goaves, which Mr. Wild spoke of, to force the gas into the return air course, and so pass it away without exposing it to lamps or candles?

Mr. WILD: Yes, that would be so.

Mr. GREENWELL asked if Mr. Wild wished it to be inferred from his argument that the forcing an increased quantity of air into a mine where there was an increase in the quantity of gas would be rather prejudicial than otherwise?

Mr. WILD said in some cases, if a party were working in the return air way, and the furnaceman without previous instructions looked to the barometer and saw a depression setting in, then if he began to fire harder——

Mr. GREENWELL (interposing): But assuming that you are working a fiery mine, in which you are not taking the return air over the furnace?

Mr. WILD: If any of the lamps were unsafe, an explosion might occur.

Mr. BRYHAM asked if Mr. Wild had ever known an instance where increased pressure of air in goaves had brought off gas in sufficient quantity to make an explosive mixture.

Mr. WILD: Yes, many times.

The PRESIDENT: That is, increased furnace power.

Mr. BRYHAM: Whether from increased furnace power or mechanical ventilation, the effect would be the same. I never in all my experience saw gas brought off in such quantity, by increased ventilation, as to make the returns unsafe, if they were not unsafe before.

The PRESIDENT said that Mr. Wild, in speaking of the ventilating power, distinctly named the furnace; but of course the fan would have the same effect. Mr. Wild did not say that the increased ventilation did it, but the increased suction caused by the increase of power.

Mr. BRYHAM: We will suppose that 10,000 feet of air is going into a certain district, where gas from the goaf is not passing off in the return in such quantities as to explode in

the lamps, then if you increase that quantity to 11,000 or 12,000 feet, would that bring out the gas in a sufficient quantity to be explosive?

Mr. WILD: That is my experience.

Mr. BRYHAM: I never had such experience; and I think it would be dangerous to let it go forth that you should work with a less quantity of air because the barometer is falling.

In answer to a further question, Mr. Wild said what he wished was that everyone should be on their guard not to allow men to be either firing shots or using naked lights, under the conditions he had described, even in places which before might have been considered perfectly safe.

Mr. BRYHAM: But where there are no naked lights in the pit, your principle I understand is this: that it would be safer to keep down the ventilation, in the event of a falling barometer and a goaf filled with gas, than to increase it?

Mr. WILD: Unless increased care goes along with it.

Mr. GREENWELL: I gather from the way you have put it that it comes to this—at the time you send word to your furnaceman if you could at the same time communicate with the men in the return air ways, and get them to come out, then you would reduce to a minimum the chances of accident; therefore, in that case, would you improve the general safety of the mine by increasing the quantity of air, or would you diminish it?

Mr. WILD: It would increase the safety.

Mr. GREENWELL: Then we are agreed that it is desirable, with proper precautions, to increase the quantity of air under such circumstances.

Mr. WILD: That is so, exercising care along with it.

Mr. GREENWELL: We must not let the idea go forth that it is necessary to diminish the quantity of air in a mine to ensure safety.

Mr. MARTIN: As I understand, what Mr. Wild objects to is a sudden increase of the ventilation without due precaution for the safety of those working in the parts that it may affect.

Mr. WILD: Yes; that is it.

Mr. HIGSON: That was not his contention. His contention was that, in passing increased volumes of air over a goaf you caused a greater exudation of gas from it, and so filled the main air ways.

Mr. MARTIN: I only understood by doing it suddenly; because he particularly mentioned that if the furnaceman, noticing the barometer falling, suddenly commenced increasing the ventilating power, he would thereby cause the danger.

Mr. HIGSON: But you do not mean for a moment to admit that goaves are or ought to be in such a condition that the mere rise or fall of the barometer should make the mine dangerous? I have never known a mine like that. My experience is that the gas precedes the indication of the barometer—that you can detect gas in the lamp before the barometer will show it.

Mr. WILD: If that be so, I contend again that the danger is increased. If the gas precedes the depression, that gas is lurking somewhere where it ought not to be, and to begin to force it out quickly through the return air-ways must be dangerous.

Mr. HIGSON: If air roads sweeping the edges of goaves are clear from gas with a given volume of air current, and if an increased ventilating pressure fouls such air passages, then it appears to me that the sectional area of such air passages must be too small for the requirements of the case, and what really takes place under such circumstances is, that the water-guage is increased greatly with very little *increment* of air current. Consequently, if the goaves are

charged with gas there is a greater exhausting power at work to suck it out with little or no increase of air current to dilute it. But if the air passages were of sufficient area to properly ventilate the mine, such a case as Mr. Wild suggests could not exist. The basis upon which he founds his argument is a palpable mining error.

Mr. BRYHAM: The question is whether by such means as increasing the power of the furnace you could possibly bring out of the goaf such an increased quantity of gas as would make the return foul. I never saw it yet. I have watched goaves that have been full of gas and have watched the effects of increased and diminished ventilation, but I never yet saw that an increased quantity of air had the effect of endangering the mine. I should not like to tell my underlookers, or fireemen, that they must slacken the current of air, in order to avoid danger. It would be a very dangerous principle to adopt.

Mr. WILD: I do not mean that at all.

Mr. BRYHAM: But you say that the effect of increasing the ventilation under certain conditions would be to increase the danger, which is much the same thing.

Mr. WILD: If a depression, in any shape or form, decreases the ventilation, what is the effect? The depression of the barometer is an indication that more gas may be expected, and if more gas is expected, and you begin to fire harder, so that that gas may be cleared away, what are we to do with it? Where does it go to?

Mr. BRYHAM: It passes off, and the increased quantity of air renders it less dangerous.

Mr. GREENWELL said: There is one more question. Supposing, for the sake of argument, that you had not drawn your men out of the air-ways—that it was necessary to keep them there after you had given the order to fire up the furnace—if those men were working with Stephenson's

lamps, would the gas in any reasonable probability explode at those lamps?

Mr. WILD: I do not think it would. I think the lamps would go out.

Mr. HIGSON, in the course of further discussion, said his experience was against Mr. Wild's theory of strong air crossings. If the crossings could be made as strong as Mr. Wild suggested,—of which there was a doubt,—it suggested the probability of transmitting the explosive atmosphere from one panel, or district, to another, and thus intensifying the mischief. An illustration of this occurred some time ago at the Brynn Hall Colliery.

The PRESIDENT said that one important point had not received the attention which it merited, namely, the proper laying out of mines.

Mr. BRYHAM: Mr. Wild's paper has very many good points, particularly the one to which you have referred—the system of laying out a mine. That is a very good point, and I think it is very likely that such a system as Mr. Wild advocates—the long wall—if generally adopted, would be found to be very good indeed, and a means, perhaps, of lessening the number of colliery disasters. Not that we shall ever do away with these altogether: I am afraid we shall not; still by a good system of working we may lessen them.

The PRESIDENT said he had seen great diversity in the laying out of mines. Some were laid out on a villainously bad system, others on a system which left no room for improvement; and there was no doubt that in ventilation and the avoidance of sudden issues of gas, everything was simplified by the proper laying out of the mine.

Mr. HIGSON: I believe you will have issues of gas independent of the system of laying out mines.

Mr. BRYHAM: Are you referring now to the long wall system being preferable to the pillar and stall.

The PRESIDENT: No; I am not giving preference to either. They are both useful in their way.

In closing the discussion, the PRESIDENT said: The paper read by Mr. Wild is on a very important subject, embracing a large number of points, and I would rather not attempt a review of the whole of those points. Mr. Wild is a mine manager of great experience; I have known him personally for a quarter of a century; and I know he has had to do with very fiery mines—mines where there have been large issues of gas—and any observation, therefore, coming from him should be listened to and considered as the result, as I have no doubt they are, of quiet observations, from which some good is to be elicited. Mr. Wild, however, has apparently not had to do with an explosion where a large amount of force has been exerted. In the first place, he seems to doubt that the force of an explosion is sufficient to strike a man dead, without his being blown against something. Now these men, who, as it were, are in the breach of a gun when an explosion takes place, are subject to the same force, comparatively, as is exerted in the breach of a cannon when it is fired. The force must be exerted there to produce the effects that occur outside. When we find that timber—from six to ten inch scantlings of sound pitch pine—is actually ripped to match-wood hundreds of yards away from the seat of the explosion, and yet not moved from its place, being merely torn and left there, there must be a force sufficient surely to annihilate all the tender construction of which the human frame is composed. I do not think there is reason to doubt that death is so produced in the case of many explosions. I have not only seen men who have been killed evidently on the spot where they have been at work, in the case he alluded to, but over and over

again where they have been struck dead simply by the pressure. In the Unity Brook explosion there were many such. Scarcely a man of them had gone a yard. In the Wood pit at Haydock many of the killed had not moved an inch from the spot where they were at work; others again, who were out of the blast, and had been making their way out, were found lying suffocated, lamp in hand. Some had been blown to pieces; others simply killed by the pressure, I think there need not be any doubt about that. Mr. Wild has not, perhaps, seen one of those great explosions where the force has been so great, as they do not frequently occur. Then, again, his experience dates from far back when many of those very fiery mines in the neighbourhood of Ashton and Oldham were ventilated with small quantities of air, and when, if an explosion did take place, there was not sufficient air to carry it to the extreme parts of the mine. With an increased quantity of air you may add greatly to the health of the miners, and decrease the deaths from consumption—a disease, which, according to a statement I saw a few days ago, is very prevalent amongst miners—but if life is prolonged by this increased ventilation, then, even though the number of lives lost by accident was as great as in the olden times—there would still be a great gain; but the lives lost by explosions now are nothing like what they were in the olden times. There is no more pleasing study to a person who takes an interest in mining than to go carefully over the accidents as they have taken place. Speaking generally, colliery accidents have been diminished. A steady diminution has been going on during the last 25 years, and in nothing is this more marked than in explosions. The actual number of explosions has greatly decreased, but the way to look at the matter fairly is to inquire what is the number of lives lost in proportion to the number employed? It will be found that there has been a diminution, not only

are there actually fewer explosions but the deaths in proportion to the number employed are also fewer. There had been an increase under some heads. A remarkable increase is apparent in the number of colliery accidents by trams and tubs. But that is easily explained. Twenty-five years ago colliery work with trams and tubs was the exception; there hardly was such a thing. It was the old basket and sled, generally without wheels, which men, and even women, dragged with a rope through the legs. Under the head of trams and tubs, then, there was a serious increase. In shafts, notwithstanding the great velocity with which men were raised and lowered, the accidents had fallen off amazingly in proportion to the number of men employed. There are now so many kind friends in the form of critics, and some of them very severe critics, looking after the miner, that every one concerned in colliery work is spurred on to measures of increased safety. I think, what with the legislation which has taken place, and the keen eye of the public upon all mining matters, attention to safety has been brought now almost to the extreme point; in fact, to carry it much further would be almost to make life miserable; people would be always miserable on this question of safety.

Mr. GREENWELL: Colliery Managers, at least.

The PRESIDENT: This point of the proper laying out of mines I consider the most important of all, and I am sorry to observe that in spite of the warnings of recent years, some who have followed a bad system have shown no disposition to adopt any better one. The mines are worked now as before. You may use safety lamps, you may avoid powder, you may think you are going to get more large coal, but unless you lay your mine out on a proper system you both lay yourself open to explosion, and you crush your coal, and will not get half the quantity of large which you would otherwise. The laying out of mines is far too little understood and practised. In Lancashire there are plenty of col-

lieries well laid out, and yet many which are badly laid out, and they continue on the same old system as though a good system were unknown. The long series of questions put to Mr. Wild about the goaf giving off gas admit, I think, of a simple answer. You cannot get up this increased vacuum without at first sucking out a large quantity of gas, and the only remedy for that, if needed, would be to reverse the ventilation—that is, make the air *blow* instead of *suck*. There is just one other point: that is, the pouring water down a pit after an explosion in order to create a current. Immediately after an explosion, no one can tell until he gets into the mine what the state of things is there. The mine may be on fire; there may be a large quantity of fire-damp; and to pour water down the first thing might be attended with great danger in sending that gas mixed with air on to the fire. In clearing out a mine—for instance, in the Wood Pit—the furnaces had to be put out, being too near the return air, and steam jets substituted, and ultimately fans. Water was poured down partly in a continuous stream, and partly by the upsetting of barrels, and each barrel of water upset caused a very perceptible and sudden increase in the air current. I thought it was a dangerous increase, so dangerous that I asked that it might be stopped, lest it should force the flame through the safety-lamps. Notwithstanding the distrust of the Davy-lamp, it is amazing to see how you have to trust your lives to it at times. In clearing out a mine like that, you cannot get to the far end of the workings, and put brattice up without some flashes in your lamp. But all sudden blasts of air and gas should be avoided, as concussion might easily send flame through the gauze; and it was to avoid the flame being sent through the gauze, at the Wood Pit, that we had the upsetting of barrels stopped. You have to be on the alert at every point in dealing with a mine where there is gas.

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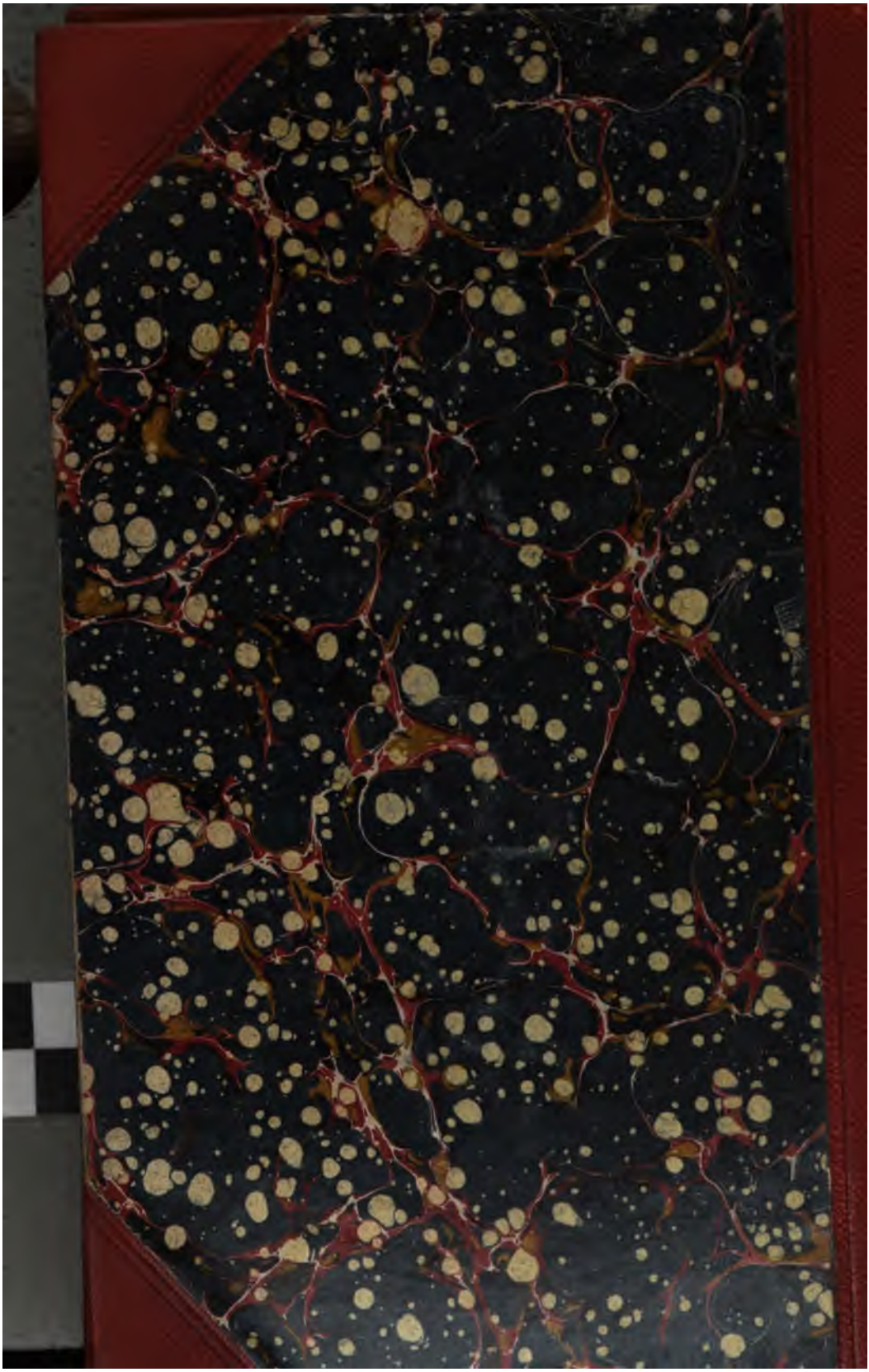
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